The Engineer

SEPTEMBER 25, 1953 28, ESSEX ST., STRAND, LONDON, W.C.2 TWO SHILLINGS

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GEORGE COHEN

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'Grams: Omniplant, Telex, London

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FOUR POINTS TO EFFICIENCY

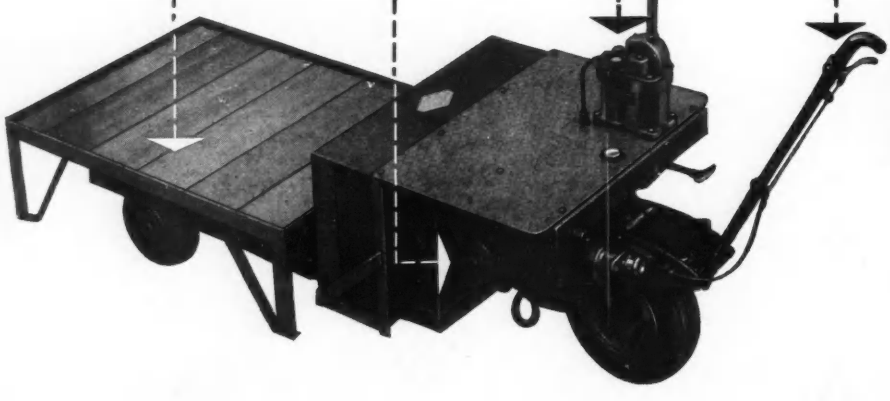
— and economy too

Only 12 inches high, the stillage table gives you an area of more than 10 square feet.

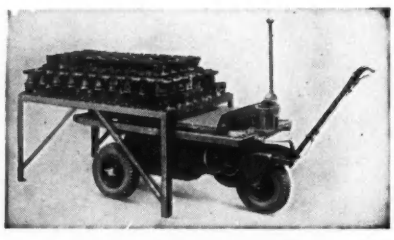
Self-contained power unit contains motor, shock-proof automatic clutch and reduction gear.

A few short strokes lift the loaded platform 4 inches. A simple release valve lets it down again.

This handle controls forward and reverse drive, steering and braking. Little skill is needed.



GRAISELEY stillage trucks will carry 20 cwts. at a time, work all day up inclines, round corners and in and out of confined spaces. After 8 or 10 miles they need re-charging with about 4 units of electricity. That's economy for you. At night they simply plug into the charger which automatically switches off when they are ready for the next day's work. Delivery is good at present. May we arrange a demonstration with your nearest service depot ?



For those who prefer a high stillage. The table has an area of 13 square feet and stands 27 inches high.

DIAMOND MOTORS (WOLVERHAMPTON) LTD. Upper Villiers Street, Wolverhampton. Telephone : Wolverhampton 21625

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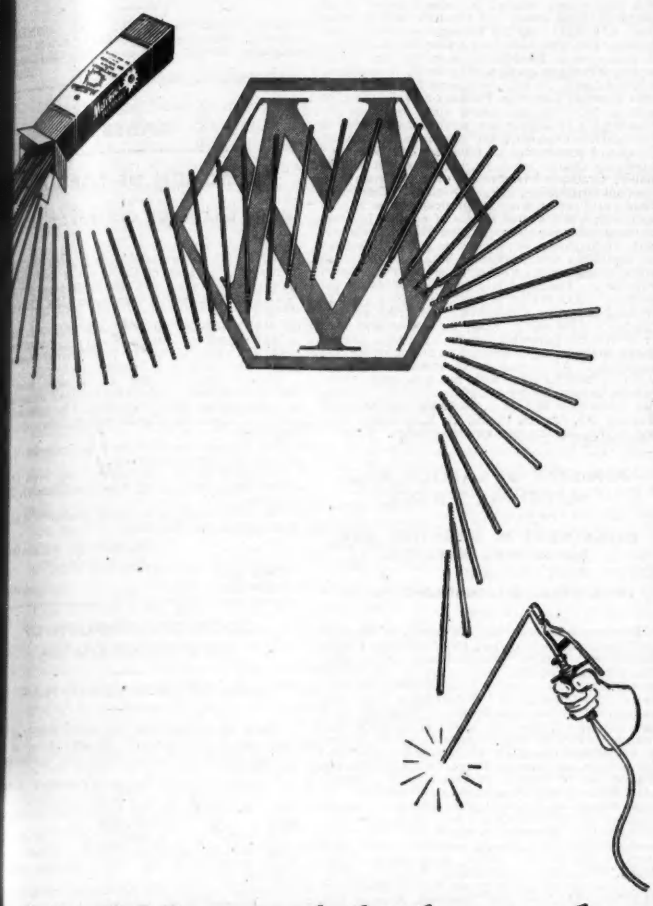

ehind Metrovick electrodes

The last word in welding rests with the operator. The man on the job knows whether an electrode is easy to use, whether he gets good penetration without undercutting, has no difficulty with slag inclusions . . . All these practical everyday points are watched in the production of Metrovick electrodes, for M-V are themselves one of the biggest users of welding in the country. In their own shops they use Metrovick electrodes exclusively. This practical experience is reflected in the quality of all M-V welding equipment and electrodes, so that for anything in welding it is always best to rely on Metrovick.

TROPOLITAN-VICKERS ELECTRICAL CO. LTD., TRAFFORD PK., MANCHESTER, 17.
Member of the A.E.I. group of companies

METROVICK *Equipment for More Efficient Welding*

L/P 001

THE ENGINEER

ESTABLISHED 1856

Vol. 196 No. 5096

SEPTEMBER 25, 1953

28, Essex Street, Strand, London, W.C.2

Telephone : CENtral 6565 Telegrams : Engineer Newspaper, Estrand, London

Published every Friday Registered as a Newspaper

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NOTICE TO READERS

All letters intended for insertion in 'The Engineer' or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications. No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.

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WORDING OF ADVERTISEMENTS: Approximately the first 25 letters of each advertisement are set in heavy type. Advertisers are therefore advised to begin their advertisements with the words they want emphasized.

Advertisements received by Mid-day Tuesday will appear in the issue of Friday the same week. Orders must be accompanied by a remittance.

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PUBLIC APPOINTMENTS

UNIVERSITY OF DURHAM

KING'S COLLEGE, NEWCASTLE UPON TYNE

LECTURESHIP IN MECHANICAL ENGINEERING

The Council of King's College invite applications for a LECTURESHIP IN MECHANICAL ENGINEERING.

Applicants should hold an Honours Degree in Engineering and should have had some industrial experience or some experience of teaching or experimental research. Preference will be given to candidates who are prepared to pursue a programme of research on diesel engines, for which reasonable time and facilities will be made available. The Lecturer may be required to give some teaching on any branch of mechanical engineering, but it is desirable that he should be willing to specialise and give lectures on engineering thermodynamics and fluid flow.

The commencing salary will be at a point on the scale £600 by £50 to £1100, in accordance with the qualifications and experience of the successful candidate. Family allowance and F.S.S.U.

Twelve copies of application, together with the names of three persons to whom reference may be made, should be submitted not later than 3rd October, 1953, to the undersigned, from whom further particulars may be obtained.

G. R. HANSON,
Registrar of King's College

E5425

UNIVERSITY OF SOUTHAMPTON

DEPARTMENT OF CIVIL ENGINEERING

SENIOR LECTURER AND HEAD OF THE DEPARTMENT

Applications are invited for the appointment of SENIOR LECTURER AND HEAD OF THE DEPARTMENT. Applicants should have had professional and teaching experience; experience in structural theory and design would be an advantage. Salary scale £1100 by £50 to £1400, plus superannuation and children's allowances.—Further particulars and details of application can be obtained from the Secretary and Registrar, The University, Southampton. E5436

THE POLYTECHNIC,

309, REGENT STREET, W.1

MECHANICAL & CIVIL ENGINEERING DEPARTMENT

ASSISTANT, GRADE B

Applications are invited for a full-time post of ASSISTANT, Grade B, in Mechanical Engineering. Candidates should be Graduates with industrial experience.

The salary scale commences at £490 per annum, rising by annual increments of £25 to £765, plus London allowance of £36 or £48 per annum with additional allowances for graduateship and training, where applicable.

The commencing salary may include increments for previous teaching, professional, and war service.

Further particulars and application form, to be returned not later than 9th October, may be obtained by sending a stamped, addressed foolscap envelope to the undersigned.

J. C. JONES,
Director of Education.

E5373

GLAMORGAN EDUCATION COMMITTEE

BRIDGEND TECHNICAL COLLEGE

ASSISTANT (GRADE A) IN AUTOMOBILE ENGINEERING

Required as soon as possible at Bridgend Technical College, ASSISTANT (Grade A) in Automobile Engineering Practice. Candidates will be required to assist with General Workshop Courses and must possess the Final Certificate in Automobile Engineering Practice of the City and Guilds of London Institute and/or qualifications in engineering workshop practice, together with experience in motor vehicle repair and servicing.

Application forms, obtainable from the undersigned on receipt of a stamped, addressed foolscap envelope, must be returned by 3rd October, 1953. Canvassing will disqualify.

EMLYN STEPHENS,
Director of Education.
County Hall, Cardiff. E5386

HERTFORDSHIRE COUNTY COUNCIL

HATFIELD TECHNICAL COLLEGE

LECTURER IN MECHANICAL AND PRODUCTION ENGINEERING

Applications are invited for the post of LECTURER IN MECHANICAL AND PRODUCTION ENGINEERING in the Works and Production Department. Applicants should be Corporate Members of a senior Institution and be able to lecture on materials, machines and other production subjects to H.N.C. level.

Salary scale: £940 by £25 to £1040.

Application forms may be obtained from the Registrar, Hatfield Technical College, Roe Green, Hatfield, to whom completed forms should be returned as soon as possible. E5409

PUBLIC APPOINTMENTS

BEDFORDSHIRE EDUCATION COMMITTEE

ENGINEERING DEPARTMENT

FULL-TIME LABORATORY TECHNICIAN

Full-time LABORATORY TECHNICIAN (Engineering Department) required at North Bedfordshire College, Bedford. National Certificate or equivalent standard essential. Starting salary within the range £330 to £525, according to qualifications and experience.

Apply immediately for further particulars to the Director of Education, Shire Hall, Bedford. E5412

FIFE COUNTY COUNCIL

COUNTY ENGINEER'S DEPARTMENT, CUPAR

ENGINEERING ASSISTANTS

Applications are invited for appointments as ENGINEERING ASSISTANTS on salary Grade VI, £480, rising by annual increments of £20 to £600 per annum. Applicants should be qualified engineers, preferably with experience in the design and construction of works relating to water supply and/or drainage. Consideration will be given to meeting the housing needs of the successful applicants.

The County Council have in hand a large programme of varied and interesting new works, including aqueducts, service reservoirs, booster stations for water supply, purification works and pumping schemes for the disposal of sewage.

Applications to be made on forms which may be obtained on request from the County Engineer, Belfield, Cupar, and which should be returned by 10th October, 1953.

MATTHEW POLLOCK,
County Clerk.

County Buildings,
Cupar-Fife,
18th September, 1953. E5432

HER MAJESTY'S COLONIAL SERVICE

PUBLIC WORKS DEPARTMENT, SIERRA LEONE

(a) EXECUTIVE ENGINEER (b) ROAD ENGINEER

Applications are invited for the following posts:—(a) EXECUTIVE ENGINEER, (b) ROAD ENGINEER, Public Works Department, Sierra Leone.

Duties for post (a) include design and construction of roads, water supply investigation, building, drainage; for post (b) taking charge of a bituminous surface dressing programme and to supervise construction, &c., of roads, culverts and bridges.

Both appointments are on contract in the consolidated scale £886–£1758 p.a. Gratuity is payable at the rate of £25 for each satisfactory three months' period of service or at £37 10s. if consolidated salary is over £1000. Commencing salary according to qualifications and experience.

Candidates should hold a recognised University Degree or Diploma in Civil Engineering carrying exemption from Parts I and II of the Institution of Civil Engineers examinations, plus two years' practical experience or be A.M.I.C.E. Full details on application.

Apply in writing to the Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, giving briefly age, qualifications and experience. Mention the reference number CDE 112/15/02–03 and the post applied for. E5461

LONDON COUNTY COUNCIL

HANDICRAFT

HANDICRAFT MASTERS FOR WOODWORK AND METALWORK

Applications invited for appointment to Council's service as HANDICRAFT MASTERS for Woodwork and Metalwork. Candidates should be qualified teachers or eligible for temporary recognition by Ministry of Education.—Apply at once on form EO/TS40, obtainable from (send stamped, addressed, foolscap envelope) and returnable to Education Officer (EO/TS4), County Hall, London, S.E.1. (1032.) E5450

NATIONAL COAL BOARD

NORTH-EASTERN DIVISION

SENIOR TECHNICAL ASSISTANT

Applications are invited for the permanent appointment of SENIOR TECHNICAL ASSISTANT in the Area Civil Engineer's Department in Area No. 3 of the North-Eastern Division, National Coal Board.

Experience in the design and construction of reinforced concrete, structural steel and general civil engineering such as roads, drainage, &c., is necessary.

Applicants should be A.M.I.C.E., A.M.I.Mun.E., or equivalent, but consideration would be given to other suitably experienced candidates.

Salary within range £500–£750 with good future prospects.

Applications, giving full particulars, should be sent within 14 days of this advertisement to the Area Administrative Officer, No. 3 Area, North-Eastern Division, National Coal Board, Wath-on-Dearne, Nr. Rotherham. E5401

PUBLIC APPOINTMENTS

ADMIRALTY

ROYAL NAVAL SCIENTIFIC SERVICE

ENGINEERS AND PHYSICISTS

ENGINEERS and PHYSICISTS (particularly with Electronics) required for appointments in (a) Senior Scientific Officer and Scientific Officer grades (Ref. A246/52A), and (b) Experimental Officer and Assistant Experimental Officer grades (Ref. A247/52A) in Experimental Establishments in London, Portsmouth, Weymouth areas, and Scotland. Candidates, British subjects, for (a) must possess First or Second-class Honours Degree in Physics or Engineering, or high professional attainments such as Corporate Membership of appropriate professional institution with suitable experience and responsibility, and for (b) should possess one of following qualifications: University Degree in Science, Engineering or Mathematics, Graduate Membership of appropriate professional institution, High National Certificate, Final Certificate of five-year grouped course in relevant subject at City and Guilds of London Institute or comparable institution, Higher School Certificate with Mathematics or Science as principal subject or equivalent qualification. S.S.O.s at least 26 years of age with at least three years' approved experience. London salary (men), £917–£1075 per annum; S.O.s at least 21 years, £440–£812; E.O.s at least 26 years, £681–£838; A.E.O.s at least 17½ years, £274–£607. Rates for women and posts in Provinces somewhat lower. Starting salaries above minima may be granted according to age and experience. All appointments unestablished (with F.S.S.U. for S.S.O. and S.O.) but with some opportunities to compete for established posts. Application forms from M.L.N.S., Technical and Scientific Register (K), Almack House, 26, King Street, London, S.W.1, quoting appropriate reference. E5395

MINISTRY OF LABOUR AND NATIONAL SERVICE

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

INDUSTRIAL ENGINEERING POSTS

Department of Scientific and Industrial Research invite applications for three INDUSTRIAL ENGINEERING POSTS (unestablished) with headquarters in London, but involving appreciable travel in the U.K., for work on industrial management and production techniques. Experience essential in one or more industrial specialities such as plant layout, materials handling, methods engineering, statistical quality control; keen interest in operational research and lecturing an advantage. 1st or 2nd Class Honours Degree in Applied Science, Engineering or Physics, or Corporate Membership of a senior engineering institution required. The appointments are for three years only and cover one senior (Ref. C.470/53A) and two other posts (Ref. C.471/53A). Inclusive remuneration (45½ hour week) within the following ranges: senior post (men) £1438–£1553; other posts (men) £1048–£1383. Rates for women slightly lower. Application forms quoting appropriate Ref. number from M.L.N.S., Technical and Scientific Register (K), Almack House, 26, King Street, London, S.W.1. Closing date, 17th October, 1953. E5393

AIR MINISTRY

WORKS DEPARTMENT

MECHANICAL AND ELECTRICAL ENGINEERS

Air Ministry require MECHANICAL and ELECTRICAL ENGINEERS in Works Department for design, operation and maintenance of ground mechanical and electrical works services on R.A.F. stations at home and overseas and civil aviation stations. Appointments in two grades: (a) Main Grade, starting salary, £970, rising by eight annual increments to £1280 per annum; (b) Assistant Grade, starting salary, age point, viz., age 25, £628 per annum, rising to £875 at age 34, thereafter rising annually to £970 per annum. Salaries somewhat lower in provinces. Appointments temporary and non-pensionable but with long-term possibilities. Special allowance up to £1300 a year according to location payable in addition to salary during overseas service. Candidates must be natural-born British subjects. Minimum qualifications and experience for both grades of posts: (i) (a) University Degree or equivalent Diploma in Electrical and/or Mechanical Engineering and at least a two-year apprenticeship or (b) Graduate or Corporate Membership of the Institutions of Mechanical or Electrical Engineers with appreciable electrical engineering experience and at least a three-year apprenticeship, and (ii) employment in responsible position for minimum of three years with well-established engineering concern providing wide experience in electrical and mechanical engineering practice.

Application forms, quoting Reference D290/52A, from M.L. and N.S., Technical and Scientific Register (K), Almack House, 26, King Street, London, S.W.1. E5394

QUANTITY SURVEYOR

TAKORADI HARBOUR EXTENSIONS, GOLD COAST

QUANTITY SURVEYOR required for Takoradi Harbour Extensions, Gold Coast Local Civil Service for one tour of twelve months. Salary, &c., up to £2020 a year. Free passages. Candidates must be fully qualified quantity surveyors with experience in measuring and costing harbour works.

Write to the Crown Agents, 4, Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience, and quote M2B/30146/EH. E5424

PUBLIC APPOINTMENTS

THE BOARD OF GOVERNORS

THE HAMMERSMITH, WEST LONDON AND ST. MARK'S HOSPITALS, DU CANE ROAD, LONDON, W.12

ENGINEERING TECHNICAL ASSISTANT

ENGINEERING TECHNICAL ASSISTA required. Salary scale £575–£67[illegible] p.a. plus Lon weighting £20–£30.—Particulars from Chief Engin E5[illegible]

TENDERS

BOROUGH OF TORQUAY

MAIN DRAINAGE CONTRACT NO. [illegible]

TENDERS are invited for the CONSTRUCTI in the built-up area of the town of the follo approximate lengths of CONCRETE and STO WARE PIPE SEWERS, together with INCIDENT WORKS:—

530 lin. yards of 33in. to 48in. dia. Concrete Se 568 lin. yards of 15in. to 24in. dia. Concrete Se 270 lin. yards of 9in. to 12in. Glazed Stonew Sewer.

Tender documents may be obtained from Borough Engineer, Town Hall, Torquay, on payme of a deposit of £5 5s., which will be refunded receipt of a bona-fide Tender and the return of all documents.

The contract drawings may be inspected at office of the Borough Engineer.

Tenders must be delivered to the Town Cl Town Hall, Torquay, by noon on Thursday, 2 October, 1953.

The Corporation do not bind themselves to acc the lowest or any Tender.

T. ELVED WILLIAMS,
Town Clerk.

Town Hall,
Torquay. E54[illegible]

COUNTY BOROUGH OF SOUTHEND-ON-SEA

SALE OF REDUNDANT PLANT

Offers are invited for the PURCHASE of following REDUNDANT PLANT lying at Sewage Disposal Works, Prittlewell, Southend-Sea:—

THREE 50 h.p. Sisson Compound Ver STEAM ENGINES for 200 p.s.i., on integral plates for direct-coupled centrifugal pumps without pumps. Dated 1914.

One 6½in. S.C., S. and S., B.G. LATHE totally enclosed headstock. 3ft. 6in. between cent Fitted 4-jaw chuck 8in. By C. Lindley and London.

Form of Tender may be obtained on applicati to the Borough Engineer and Surveyor.

Sealed Tenders, addressed to the undersigned endorsed "Sewage Works Plant," to be deliv to this office not later than 12th October, 1953.

No Tender will be received except in the spe envelope provided, which shall not bear any m indicating the sender.

The Corporation do not bind themselves to acc the highest or any Tender.

ARCHIBALD GLEN,
Town Clerk.

E5423

MIDDLESEX COUNTY COUNCIL

MAIN DRAINAGE DEPARTMENT

CONTRACT NO. M.8A—GASHOLDER, MOGDEN WORKS

TENDERS are invited for the SUPPLY a ERECTION of 4 No. STEEL GASHOLDERS a 4 No. PIPE SUPPORT TRUSSES for 70ft. diame Digestion Tanks at the Mogden Works.

Forms of Tender, general conditions, specificati schedule and drawings may be obtained from Chief Engineer, County Main Drainage Departme Mogden Works, Isleworth, Middlesex.

Sealed Tenders, in envelopes provided, bearing name or mark indicating the sender, must be deliver to the office of the undersigned not later than first post on 5th October.

The County Council does not bind itself to acc the lowest or any Tender.

CLIFFORD RADCLIFFE,
Clerk of the County Council.

Guildhall,
Westminster, S.W.1. E547[illegible]

INDIA STORE DEPARTMENT

LOCOMOTIVE BOILERS

The High Commissioner for India invites TE DERS for the SUPPLY of:—

EIGHT LOCOMOTIVE BOILERS, Metre Gaug "B" Class.

ONE LOCOMOTIVE BOILER, Narrow Gaug "K" Class.

Forms of Tender may be obtained from t Director-General, India Store Department, 32/4 Edgware Road, London, W.2, at a fee of 10s., whi is not returnable.

Tenders are to be delivered by 2 p.m. on Frid 27th November, 1953.

Please quote Reference H. No. 4426/52 in yo application. E540[illegible]

THE ENGINEER

SEPTEMBER 25, 1953

Birmingham Engineering Centre

EARLY in the New Year there will be opened in Stephenson Place, Birmingham, a permanent engineering centre. For this purpose the building of the Birmingham Exchange is now undergoing reconstruction at a cost of some £25,000. The Exchange was founded in 1861 to serve what were then the basic industries of the area, coal, iron and steel ; and for very many years it proved very successful. But as engineering industries concentrated around Birmingham the original purpose of the Exchange became less important. It has therefore now been decided that the Exchange, without wholly giving up its previous activities, shall transfer its main work to the fostering of the newer engineering industries instead of the old basic ones. The City of Birmingham Public Works Committee, the Regional Controller of the Ministry of Supply and a number of Midland industrialists have all signified their interest in the project. The Centre will consist of a permanent engineering exhibition and a technical information service, which will be designed to facilitate co-operation between manufacturer and buyer. It will be run strictly on a "non-profit-distributing" basis. It is intended to give every encouragement to foreign trade representatives, consuls and the foreign press, and to assist British manufacturers, particularly the smaller firms producing goods of high quality, to contact the foreign buyer. All British firms manufacturing engineering or allied products will be eligible to exhibit and space will be available for approximately 200 firms. An active and up-to-date catalogue and technical inquiry service will be maintained, whose chief function will be to stimulate home and foreign interest, mainly for the benefit of exhibiting firms. Admission to the Centre will be free and open to all. A specially prepared hall will be available for private short-term exhibitions, and lecture rooms will also be provided for trade and technical association meetings, &c. The library will include over 5000 engineering catalogues, and a comprehensive collection of directories, reference books, and agents' registers, together with a complete set of British and American Standards. The Exhibition Manager is Mr. A. J. Cox, and inquiries about the Centre should at present be directed to Sidney-Barton, Ltd., Broadway Chambers, 7, Ludgate Broadway, London, E.C.4.

Roads and Industry

THE Association of British Chambers of Commerce has submitted to the Minister of Transport a memorandum setting out some views on the condition of this country's roads, which it has formulated as a result of a recent survey of the matter. The memorandum claims that the free movement of industrial traffic is badly impeded by numerous outdated and inadequate roads and bridges, and that very severe wear and tear are caused by widespread inferior road surfaces. Grave concern is expressed at the serious handicaps to national productivity and the hampering effect on the country's export trade caused by congestion and delay on the roads. The memorandum goes on to suggest that with the increasing volume of traffic the facilities afforded by existing roads and bridges are generally inadequate to the modern needs of industry, commerce and transport, the result being that in many key areas industrial and commercial traffic is seriously impeded. The Association has put forward a number of detailed suggestions for the improvement of maintenance and the development of roads. Commenting on the difficulty of deciding between the conflicting claims of areas and localities, the memorandum says that priorities might be decided better by considering which kind of road works can best alleviate the existing situation and then to proceed with these as a national problem in whatever locality they might be necessary. It is also urged that road surfaces could be maintained in better condition if there was closer co-operation between public utilities in excavations for the repair and development of communications. This, it is claimed, would reduce the amount of first aid repairs necessary, thus releasing men and materials for other works. Finally, the memorandum criticises the cuts in road maintenance grants to local authorities and recommends a national approach to the road problem. In so doing, the Association expresses support of the suggestion of the Select Committee on Road Estimates that the Government should re-examine the procedure at present used in framing estimates for expenditure on roads.

Transport Appointments

FOLLOWING consultation with the chairman of the British Transport Commission, the Minister of Transport has appointed Mr. John Elliot to be the chairman of the London Transport Executive, in succession to Lord Latham, who will retire from that office on September 30th. Mr. Elliot has been chairman of the Railway Executive since January, 1951, and prior to nationalisation spent twenty-two years with the Southern Railway. He joined the Southern in 1925 to take charge of public relations, becoming subsequently traffic development officer, assistant traffic manager, deputy general manager, and acting general manager. The Minister of Transport has also announced the appointment of Mr. J. C. L. Train, M.I.C.E., and Sir Reginald Wilson as full-time members of the British Transport Commission, and of Sir Harry Methven as a part-time member. Mr. Train, who was formerly chief engineer of the London and North Eastern Railway, has been a member of the Railway Executive since its inception in 1947. He began his railway career in 1908 as a pupil under the late Mr. James Bell, chief engineer of the North British Railway, and in 1912 was appointed to a post in London under Mr. C. J. Brown, who was at that time chief engineer of the Great Northern Railway. After service in the first world war, Mr. Train became personal assistant to the chief engineer of the G.N.R. and, following the grouping of the railways, held various appointments in the maintenance and civil engineering sections of the L.N.E.R. He became chief engineer of that company in 1941. Mr. Train is a member of the council of the Institution of Civil Engineers and a past-president of the Permanent Way Institution. Sir Reginald Wilson is the Comptroller of the British Transport Commission and was formerly Director of Finance in the Ministry of Transport. Sir Harry Methven, the newly-appointed part-time member of the Commission, has for some time been chairman of the Hotels Executive.

Institute of Marine Engineers' Presidential Address

ON Tuesday of this week Sir Gilmour Jenkins, K.C.B., K.B.E., gave his presidential address to the Institute of Marine Engineers and chose for his subject "Shipping and the State." In his opening remarks he commented that the shipping industry, due to its international character, differs from industry generally, since matters of foreign policy were often involved and both the protection of crews and passengers, and the supervision of ship construction, were matters calling for regulation by Government. Earlier civilisations in the Mediterranean had maritime laws which were recorded in the Rhodian Sea Law and later incorporated in the Codex of Roman Law of the Emperor Justinian, and Sir Gilmour paid tribute to the early navigators from whose voyages stemmed our rise to be the foremost maritime nation. In the early days few laws existed but, the president said, the rapid expansion of the fleet in the nineteenth century gave rise to many problems requiring legislature and saw the beginning of a change in the relationship between shipping and the State. Mercantile affairs were placed in the hands of one department, which produced a comprehensive Merchant Shipping Act, appointed surveyors at the ports and required masters, mates and engineers to obtain Certificates of Competency. The newly-formed Marine Department provided some order and coherence in Government policies, nevertheless, Sir Gilmour recalled that Samuel Plimsoll had to conduct a campaign to establish the "Plimsoll Mark" as a measure of increased safety. Events moved rapidly towards the end of the century and the president went on to describe the work of the Merchant Shipping Advisory Committee, which resulted in establishing the British Government as the most fitting to take the lead in establishing international standards of safety. He outlined the work of the first International Conference in the Safety of Life at Sea in 1913–14, of the second in 1929 and of the third in 1948, and went on to comment upon the co-operation which was gradually established within the industry itself and between the industry and the Government. To-day, he maintained, the personal relations between the various shipping interests were so close that there was no need for a committee to ensure consultation, and instanced the close collaboration between representatives of the various shipping and shipbuilding organisations which enabled the British team to attend the third International Conference not only with a fully agreed and constructive set of proposals but also in the knowledge that it had the unanimous support of the industry.

Commonwealth Conference on Aeronautical Research

THE third meeting of the Commonwealth Advisory Aeronautical Research Council, which opened in London on August 31st, ended on September 19th. The meeting, which was held under the chairmanship of Professor A. G. Pugsley, chairman of the Aeronautical Research Council, was attended by delegates from the United Kingdom, Australia, Canada, India, and New Zealand. Ceylon and Pakistan, although invited, were unable to appoint delegates. The council was set up in 1946 to review the progress of aeronautical research within the Commonwealth in order to advise on the broad planning of programmes and on the facilities required. Among the subjects discussed at this recent meeting were the new problems arising from high-speed flight and the possibility of providing a Commonwealth pool of aircraft for flight research ; the impact of new materials, which is governing advances in many fields ; the future aerodynamic efficiency of the seaplane ; the engineering problems of conditioning aircraft for human occupation and control ; the scientific problems of aircraft noise ; and the importance of Commonwealth co-operation in the study of air gusts at high altitudes. Sir John Cockcroft, chairman of the Defence Research Policy Committee of the Ministry of Defence, who opened the discussions, stressed the value of Commonwealth conferences of this kind and of visits by scientists from one country to another. The considerably increased facilities now available within the Commonwealth for wind tunnel research on aerodynamics and other aeronautical subjects have resulted to a large extent from the detailed co-ordination scheme established by the two previous meetings of the council. The next meeting of the council is expected to take place in 1955.

A Short History of Spectroscopy

By T. W. CHALMERS, D.Sc., M.I.Mech.E.

No. VIII—STEFAN'S LAW OF TOTAL RADIATION

(*Continued from page 360, Sept. 18th*)

THE amazing developments made during the nineteenth century in the field of spectroscopy reacted on nearly every other branch of scientific study. The century opened with the momentous discovery of the invisible infra-red and ultra-violet extensions to the solar spectrum. From that point onwards progress was rapid and vast.

Scientists soon realised that in spectroscopy they had an extremely refined method of distinguishing one chemical element from another—far exceeding the refinement possible by ordinary chemical analysis. With its powerful aid they succeeded in disclosing the existence of a number of elements previously unknown such as caesium, rubidium, gallium and thallium.

They turned their spectroscope on to the heavenly bodies and reaped a rich harvest of new knowledge. In 1868 Lockyer was able to announce that by means of spectroscopic analysis he had detected in the sun a "new" element which he called "helium." Nearly thirty years later Ramsay, in 1895, discovered its terrestrial occurrence in the mineral "cleveite." Other reported observations of "new" non-terrestrial elements likewise proved to be erroneous, a notable example being "nebulium," which, on the strength of spectroscopic evidence, was believed to occur only in the gaseous nebulæ. That belief persisted until 1927 when it was established that the lines in the spectrum of "nebulium" were given by oxygen or nitrogen in a highly ionised state resulting from the exceptional temperature and pressure prevailing in the gaseous nebulæ.

To-day, there is no evidence that the extra-terrestrial universe contains any element which does not occur on the earth, a fact of at least as much cosmological significance as would be the demonstration of the converse.

Beyond the strictly chemical applications of spectroscopy the astronomer's studies were aided by it as a means of measuring the temperature and distance of the stars and the velocity with which they were moving radially away from or towards the earth. Previously without spectroscopy he could at the most observe only their velocities at right angles to the line of sight.

Almost incredible as were the triumphs of spectroscopy in these and other directions during the hundred years following 1800, physicists, as the century drew to its close, found themselves faced with an outstanding problem which perplexed them. Since light, visible or otherwise, represented a flux of energy, it was very natural to inquire in what manner the energy was distributed within the spectrum. Was it equally or unequally divided among the various wavelengths composing the spectrum, and if unequally what was the pattern of the distribution and was the pattern always the same under different conditions such as change in the temperature of the emitting body?

The problem here presented may appear to be one very largely of purely academic interest, but before it was solved its study was to have momentous consequences—nothing less, in fact, than a revolution in physical science which was to have repercussions in fields widely remote from that in which it originated.

By or about the year 1880 a good deal of information bearing on the problem had been collected. The first fact connected with it had been supplied by Herschel's discovery that a thermometer exposed to the longer wavelengths towards the red end of the solar spectrum indicated a higher temperature than it did when exposed to the shorter wavelengths towards the violet end. The inference was that the energy or heat content of a parcel of rays was dependent upon the wavelength associated with them. Herschel's observations covered a very limited range and made little pretence to being quantitative, but so far as they went they seemed to suggest that the heat content *increased* with the wavelength of the rays.

Next we have to record an experiment made a few years later by Dulong and Petit. Placing a large mercury thermometer in a container preserved at 0 deg. Cent. they studied its rate of cooling when it was initially heated to various degrees, the highest of which was 280 deg. Cent. Assuming that the cooling was due entirely to radiation and not to conduction or convection of heat from the thermometer, they calculated from a knowledge of the specific heats of mercury and glass the rate at which the thermometer was radiating heat energy at any temperature reached during the cooling process.

In 1858 Kirchhoff made a crucial contribution to the practical study of heat radiation.

The spectrum of an element—typically of a metal—consists of a number of isolated bright lines separated by intervening dark lines or spaces. The bright lines represent the emission of energy. The dark lines correspond with the absence of energy emission. Each element, according to its particular spectrum, thus presents us with a particular pattern of energy distribution.

It is clear that a methodical investigation of "the distribution of energy in the spectrum" ought to be based on a study of a body emitting a spectrum containing all wavelengths from the highest to the lowest, that is to say, a "complete" spectrum without dark lines representing certain wavelengths at which there is no emission of energy. Having discovered the manner in which the energy is distributed in such a spectrum we can reasonably hope to obtain some guidance as to its distribution in the many different "incomplete" spectral patterns containing dark lines, each one of which presents us with a separate aspect of the general problem.

The question now arises: is there any body which when excited by heating or otherwise emits a "complete" spectrum in which all wavelengths are present and there are no dark lines? Physicists searched in vain for such a body. The nearest approach to one was, they found, incandescent lamp black.

The ideal body was one which should absorb all the radiation incident upon it without reflecting or transmitting any portion of it and when raised to incandescence by the absorbed energy should re-emit it without suppressing any wave-length.

Such an ideal substance came to be called a "black body." This term may be a little misleading. It is, however, a justifiable generalisation of the use of the word "black." Within the range of visible light a body is described as black if it absorbs all the light incident upon it and reflects none. The generalised use of the word merely extends this connotation from the range of visible to invisible radiation.

A preferable term for the ideal body is "a full radiator," implying that when excited it emits a full or complete spectrum. This usage avoids the erroneous interpretation of "black body radiation" as in every case being uncoloured. A heated black body may emit uncoloured radiation but with increasing heat it will, like any other body, glow, with visible colouration passing from red to yellow and finally to white.

Although no substance which precisely fulfils the definition of a "black body" is known, Kirchhoff in 1858 discovered how one could be simulated in a convenient practical manner*. Kirchhoff showed that if a hollow cavity or furnace, with insulated walls, were raised to a uniform temperature the radiation emitted through a small hole in the walls was "black body" radiation. It contained radiant energy of all wavelengths in proportions which were found to depend solely on the temperature of the enclosure and to be independent of the material nature of the walls or of the presence or absence of any body or substance of whatever kind within the enclosure.

Kirchhoff's observation is demonstrated in practice by the fact that if a body of any kind is placed in a uniformly heated furnace and allowed to acquire the same temperature as the furnace its outlines become invisible against the background of the furnace walls. In other words, the radiation from the body becomes indistinguishable in composition from the radiation from the walls.

In passing we may note that the phenomenon discovered by Kirchhoff finds one practical application in Féry's "total radiation" pyrometer, in which the radiation emerging from a sight hole in a furnace is focused on a thermocouple junction. The temperature indicated by the junction corresponds to the intensity of the radiation which in turn is a measure of the temperature of the furnace. The reading obtained is independent of the nature of the material inside the furnace and of that of which the furnace walls are composed.

A second application of Kirchhoff's discovery is to be found in the "disappearing filament" type of pyrometer. In this instrument the radiation is viewed against the filament of an electric lamp, the current through which is adjusted until the filament disappears against the background of the radiation. At the point of disappearance the temperature of the filament, calculated from the current flowing through it, is a direct measure of the temperature of the radiation.

In 1879 Josef Stefan, professor of physics at Vienna, analysed Dulong and Petit's experimental results and deduced from them a law which, he said, gave the relationship between the absolute temperature of a body and the intensity of the radiant heat energy which it emitted. This law was

$$I=\sigma T^4,$$

where σ is a constant. It is applicable strictly to the radiation emitted by an ideal "black body." Stefan was aware of the fact that Dulong and Petit's mercury thermometer inside a container did not give exactly the requirements of "black body" radiation.

* All observations are consistent with the supposition that the interior of the sun is in the condition of a black body or full radiator but the effect of the sun's absorbent atmosphere will apparently always prevent direct positive spectroscopic examination of its interior.

His law must therefore be regarded as including a correction for any deficiency in this respect involved in the experimental data on which it was founded.

In view of its importance it is desirable to be quite clear about the meaning of Stefan's law. The quantity I stands for the *intensity* of the energy emitted by a black body at a temperature T; that is to say, it represents the *amount* of energy, in ergs, radiated per second from 1 square centimetre of the surface of the body. Secondly, to this intensity or unital amount of energy all the wavelengths included in the radiation contribute their quota. The total energy I emitted by the body per second per square centimetre of its surface may be regarded as divided among a large number of elemental parcels, each associated with, and identified by, a different wave length. Stefan's law gives us the aggregate energy in all the parcels. It tells us nothing, nor can anything be deduced from it, regarding the proportions in which the energy is distributed among the different parcels; that is to say, among the different wavelengths.

From 1879 onwards the confirmation of Stefan's law of total black body radiation and the evaluation of the constant σ engaged the attention of many experimenters. Various methods were employed. That used by Kurlbaum in 1898 may be taken as typical.

Kurlbaum arranged a Wheatstone bridge with three of its arms made of manganin wire and the fourth of blackened platinum strip. With the bridge initially in balance the platinum arm was exposed to the radiation from a black body and the change produced in its resistance as indicated by the swing of the galvanometer was noted. The platinum arm was then shielded from the radiation and the bridge current increased to the amount required to produce the same galvanometric swing as that caused by the radiation in the first instance. Thus during the first part of the experiment the platinum arm of the bridge was used to indicate the temperature of the radiation falling on it and during the second the increase of current through it permitted the energy required to give it the same temperature to be calculated.

As a result of many similar experiments Stefan's law has now been fully confirmed and the value of the constant σ has been fixed at $5{\cdot}72$ to $5{\cdot}73\times10^{-5}$ in terms of ergs per second per square centimetre. In 1884 Ludwig Boltzmann of Vienna succeeded in proving that Stefan's fourth-power law could be deduced theoretically from purely thermodynamic reasoning. Thus to-day it is accepted on both empirical and theoretical grounds as an accurate expression of fundamental truth.

Stefan's law must be considered in conjunction with the "theory of heat exchanges" advanced by Pierre Prévost of Geneva in 1792. In modern terms Prévost asserted, in effect, that all bodies, whatever their nature, radiate heat at a rate determined solely by their temperature and independently of their surroundings. Thus a hot body A in proximity to a cool body B radiates heat to B at a rate determined by its temperature and, at the same time, receives from B radiant heat at a rate determined by B's temperature. Neither rate is affected by the presence or absence of the other body. If the two bodies are in the state of thermal equilibrium A will be receiving heat from B at the same rate as it radiates heat to B, and vice versa. If they are at unequal temperatures, the hotter body A will cool as a result of radiating to B more heat in a given time than it receives from B, and B will grow warmer by the reverse process.

Applied in conjunction with Stefan's law the significance of Prévost's theory is that if we have two bodies A and B at temperatures T_1 and T_2 respectively, then A will radiate heat to B at a rate σT_1^4 and will receive heat from B at a rate σT_2^4. The rate at which A loses heat will therefore, on balance, be $\sigma(T_1^4-T_2^4)$, and will be equal to the net rate at which B gains heat.

It is of interest to note that Prévost, a believer in the caloric or material nature of heat, devised his theory as a means of avoiding the complementary assumption that cold was a similar, but distinct, material substance which some contemporary physicists were calling "frigoric." It is probable that it was Prévost's theory of heat exchanges that inspired Dr. Joseph Black to pronounce the opinion that there was "no reason for considering cold as anything but a diminution of heat," that was to say, in the language of the time, cold was produced by the efflux of caloric.

To-day, although our ideas regarding the nature of heat have completely changed Prévost's theory of heat exchanges is still accepted as expressing a fundamental truth.

(*To be continued*)

The Engineering, Marine and Welding Exhibition

No. III—(*Continued from page 359, Sept. 18th*)

IN continuation of our articles on the Engineering, Marine and Welding Exhibition at Olympia, some further exhibits are described below. The exhibition was open from September 3rd to 17th.

THE ENGLISH ELECTRIC COMPANY, LTD.

On its stand the English Electric Company, Ltd., Rugby, showed three engines, representative of the range built by the company, including a diesel alternator set, a rail traction diesel engine generator set, and a dual-fuel engine. The alternator set consists of a 260kW alternator driven by a Mk. 6RK, four-stroke diesel engine, having a bore of 10in by a 12in stroke, and a normal rating of 372 b.h.p. at 600 r.p.m. An example of the company's standard traction products was the power unit consisting of a "12 S.V.T." four-stroke, solid-injection engine, with twelve cylinders arranged in two banks at an included angle of 45 deg. and having two Napier turbo-pressure chargers bracket mounted over the generator. The engine develops a maximum of 1500 b.h.p. and has a speed range of 420 to 850 r.p.m., and drives a flange-mounted main generator.

The main exhibit was a Mk. 8RLD industrial dual-fuel engine, which can be seen in Fig. 30, and which has a bore of 15in by a stroke of 20in. It is capable of developing 1100 b.h.p. at 428 r.p.m. It is one of a number of engines to be installed at the Point of Ayr Colliery of the North-Western Division of the National Coal Board. The engine is to be mounted in the colliery power station to meet the demands of the electrical equipment and will utilise as fuel the methane gas emitted from the coal seams. Meehanite castings are used for the bed-plate and the crankcase, which is stiffened by internal flanges and has large detachable access doors, while the cylinder liners, which are finished ground in the bores, are of a special grade of alloy cast iron. Alloy iron castings form the cylinder heads, which house an exhaust valve and inlet valve cage assemblies, a fuel injector nozzle and a pressure relief valve. Heat-treated aluminium alloy pistons are fitted having three compression rings and one scraper ring above the gudgeon pin and an additional oil control ring on the skirt. The forged steel connecting-rods have phosphor-bronze small-end bearings in steel bushes and white-metal-lined steel shell big-end bearings, while main bearings—split steel shell bearings lined with white metal—carry the forged steel crankshaft.

The camshaft, which is supported in split

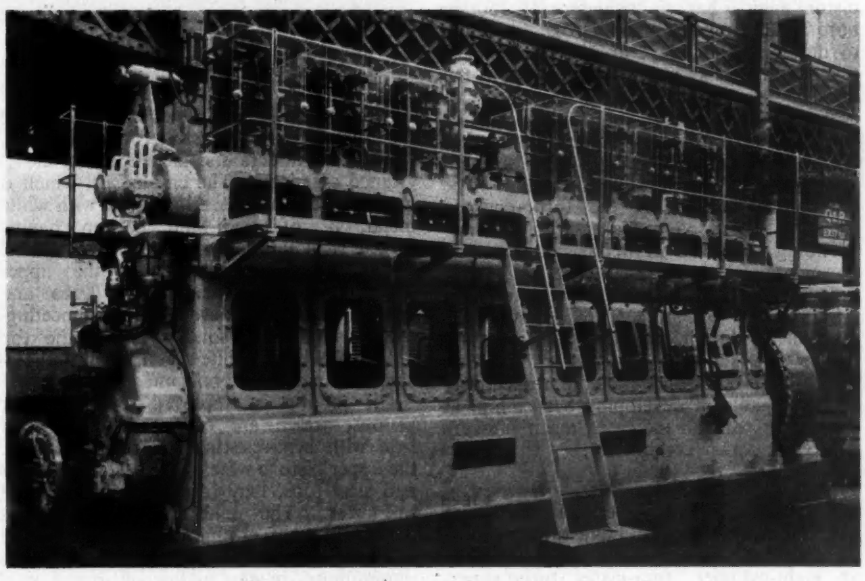


Fig. 30—Dual-Fuel Engine—English Electric

cast iron white-metal-lined bearings, is driven by spur gears from a chain-driven layshaft and operates the valves, which are Stellited at the tip, through short push rods. The engine is basically a mechanical injection engine with gas/air mixing apparatus applied to the air intake system, and for dual-fuel operation the normal fuel equipment is used to provide a pilot injection of oil to ignite the gas. Pressure lubrication of the engine is by gear pump, which draws the oil from the sump tank and delivers it through an oil cooler.

An associated exhibit was a circuit breaker with exciter cubicle and a number of industrial motors, including a motor for the chemical industry, which represents a number of such units covering from 1 to 20 h.p. The unit shown was a 2·5A, 400V, three-phase, 50-c/s motor of 1½ h.p. at 1415 r.p.m., and is of all cast iron construction externally to avoid corrosion, while there is a plastic cooling fan and the windings are quadruple dipped.

Burmeister and Wain

Burmeister and Wain, Copenhagen, Denmark, showed two working scale models of its engines, and a model of a ship, the "Songkhla," which was built by the company, and fitted with a direct reversible, single-acting, poppet valve, two-stroke, seven-cylinder, turbo-charged crosshead engine.

The engine models represented the latest development of the Burmeister and Wain two-stroke, single-acting, crosshead diesel engines, one being a poppet valve engine and the other being of opposed-piston design, and both being provided with exhaust turbo-supercharging. The poppet valve engine has six cylinders of 740mm bore by 1400mm stroke, and has a continuous rating of 7100 b.h.p. at 125 r.p.m., while the opposed piston engine has six cylinders of 750mm bore by 2000mm combined stroke and rated to develop 9900 b.h.p. at 120 r.p.m. The turbo-charging system is based upon the impulse principle so that a maximum of energy is transferred to the turbine wheel to enable it to operate with large quantities of air resulting in a low heat flow through the engine and low fuel consumption. The increase in output of the turbo-charged engine is about 35 per cent with a corresponding reduction in weight, on a horsepower basis of about 25 per cent.

The machinery fitted on board the "Songkhla" was the first exhaust gas turbo-charged unit, designed as such, and the seven-cylinder engine has a bore and stroke of 740mm and 1600mm respectively and is capable of developing 8756 b.h.p. at 115 r.p.m. with an indicated mean pressure of 8kg per square centimetre.

Harland and Wolff, Ltd.

The engineering and electrical products of Harland and Wolff, Ltd., Belfast, were shown on two stands, one of which was occupied by an eight-cylinder, four-cycle, turbo-supercharged diesel engine coupled to a Harland and Wolff alternator. This set, which we illustrate in Fig. 31, is to be installed in the Blackpool power station of the British Electricity Authority and has an output of 1280kW at 333 r.p.m. with the alternator supplying current at 6600V.

The engine has a bore of 400mm diameter by 600mm stroke and each water cooled cylinder cover, of close-grained cast iron, has two inlet and two exhaust valves, the valves being operated in pairs by rocking levers acting on a guided yoke, and supported by needle bearing fulcrum pins. Monobloc castings in two sections bolted together form the engine frames and are fitted with removable semi-circular seated camshaft bearings, while the dry sump bed-plate is of cast iron. The cylinder liners are of pearlitic cast iron and the pistons are oil cooled, the oil being circulated by the forced lubricating oil pump, which is directly driven from the free end of the engine, through a multi-tubular oil cooler.

The fuel system includes scroll plunger control and the valves have lapped spindles and conical seats. The four-valve cylinder head design is particularly suitable for pressure charging and the Napier exhaust-gas turbo-charging unit consists of a single-stage centrifugal blower coupled to a single-stage impulse turbine. Heat-resisting meehanite is used for the turbine casing and the air impeller is an aluminium forging, while the rest of the parts are also of heat-resisting material.

Another power station unit is shown as a model and consists of a six-cylinder, two-cycle, opposed-piston trunk engine coupled to a three-phase alternator having a continuous output of 2850kW at 231 r.p.m. two exhaust turbo-chargers, instead of positive displacement engine-driven blowers, will develop 8500 b.h.p. A model of a two-cycle, single-acting, trunk piston main propulsion engine of opposed-piston design was to be seen and also a model representative of a number of ships' auxiliary engines. Among the other exhibits was a model of a gas turbine driven blower, for installation in a sewage disposal works. This blower will deliver 25,000 cubic feet of free air per minute at 7·5 lb to 9 lb per square inch. Representing the range of Cooper-Bessemer units, for service with oil refineries, chemical process plants and general compressor duties, built by the company, was a horizontal two-cylinder compressor, which can be driven by either electric motor, steam engine or other prime mover. The compressor has a stroke of 9in and is capable of delivering 1000 cubic feet of hydro-carbon gas or air at a pressure of 275 lb per square inch when driven at 500 r.p.m. Other units are built having strokes of 10½in and 14in, respectively, and are capable of absorbing

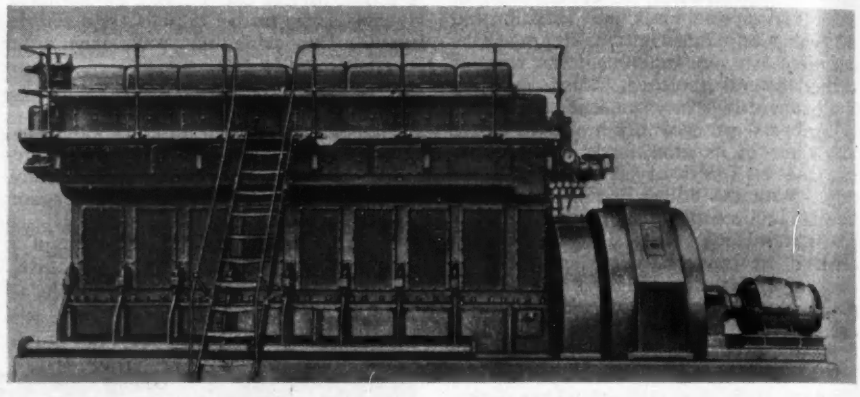


Fig. 31—1280kW Diesel Alternator—Harland and Wolff

The engine bed-plate frames and entablature are all of fabricated steel, stress relieved, while the cylinders and jackets are of close-grained cast iron. The crankshaft, which is carried in cast steel bearings lined with white metal, is of semi-built pattern having forged steel journals shrunk into cast steel units formed to incorporate the upper piston eccentrics, main crank webs and pins. Forged steel is used for the connecting-rods, which have solid eyes for the top bearings of steel, white metal lined, and tee-shaped flanges at the bottom.

Oil cooling is employed for the lower pistons, which are of special grade cast iron with heat-resisting steel crowns, while the upper pistons which have cast iron bodies and steel tops, may be cooled by either oil or water. The mild steel camshaft has hardened steel fuel pump cams and is driven by roller chain from the crankshaft. Separate pump units, having bodies of forged steel and plungers of nitrided steel working in hardened steel liners, supply fuel to the fuel valves, which have oil cooled nozzles. At the back of this engine are mounted two Napier turbo-blowers each fitted with a Serck air cooler and each supplying scavenge air to three cylinders.

The company also exhibited a six-cylinder model of its two-cycle, single-acting, crosshead, opposed-piston engine which has cylinders of 750mm diameter by 1500mm stroke for the main pistons and 500mm for the exhaust pistons, which are driven by eccentrics and side rods. This engine will develop a continuous service power of 7000 b.h.p. and when fitted with from 250 to 5000 b.h.p. and of delivering gas at pressures up to 15,000 lb per square inch.

Henry Widdop and Co., Ltd.

A four-cylinder Mk. G.M.B.4 two-stroke marine diesel engine, illustrated in Fig. 32, having a continuous output of 440 s.h.p. at 300 r.p.m. and a bore and stroke of 12½in by 18½in, was exhibited by Henry Widdop and Co., Ltd., Keighley, on the stand of Associated British Engineering, Ltd. The engine operates with pressure scavenging, the air being supplied by a double-acting piston pump, chain driven from the after end of the crankshaft. Cast iron is used for the bed-plate and also the crankcase, which is a single casting held down by tie bolts, while the cylinders are individual castings of close-grained cast iron, separately bolted to the crankcase. The cast steel cylinder heads enclose a conical-shaped combustion chamber and the pistons, which are of special wear-resisting cast iron, are cooled by oil from the main lubrication system. The connecting-rods are machined from solid steel forgings and have a phosphor-bronze bush at the small end, and big-end bearings of solid gun-metal castings lined with white metal. The crankshaft, which is machined from a single acidic steel forging, is carried in steel shell bearings lined with white metal.

A chain from the crankshaft drives the camshaft, which drives the centrifugal governor enclosed within the cambox. High-pressure pumps supply fuel to the fuel injector, which is fitted with a multi-hole sprayer and is centrally placed in the cylinder

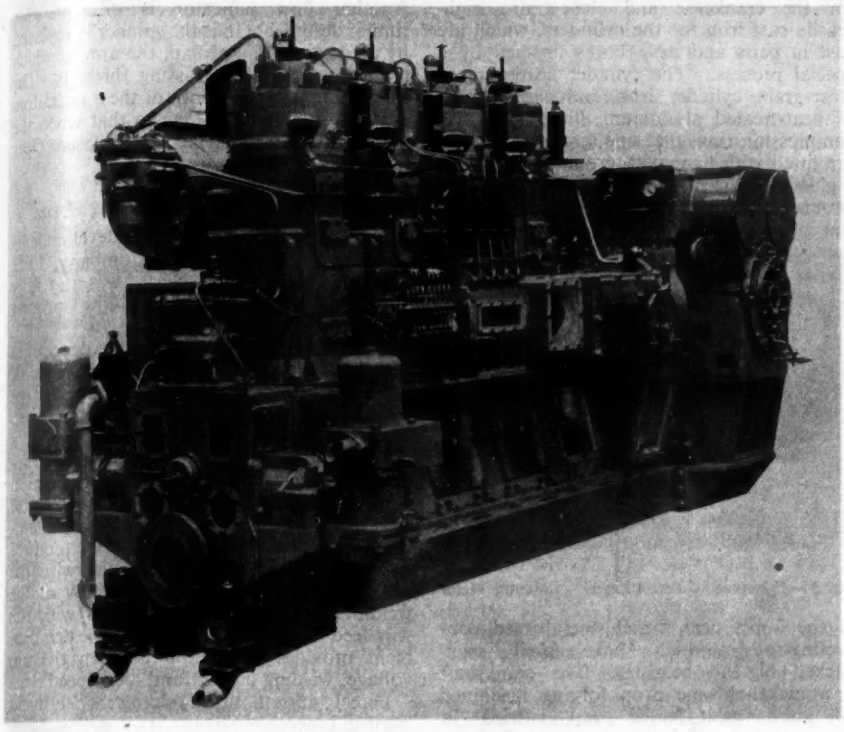


Fig. 32—440 S.H.P. Diesel Engine—Widdop

head and surrounded by a water-cooled spigot. Lubrication of all bearings and drives is effected by two plunger pumps running at reduced speed ; one pump delivers oil from the sump to the lubricating oil tank and the other delivers oil to the bearings, so that the main oil system operates on the dry sump principle. A separate system lubricates the pistons and cylinders. A plunger pump running at half the engine speed circulates the cooling water and a similar pump is provided for bilge pumping, both being mounted at the forward end of the engine. An air compressor is fitted integral with the engine. Control is by a single lever and the engine is started by compressed air stored in air receivers at 350 lb to 400 lb per square inch.

This engine, which has a fuel consumption of 0·38 lb per brake horsepower per hour, is also built with five, six, seven and eight cylinders, each cylinder being rated to deliver 110 s.h.p., and is also manufactured with a bore and stroke of 8½in by 13½in. This smaller Mk. E.M.B. engine is available with four to eight cylinders, giving a power range of 200 s.h.p. to 400 s.h.p.

Department of Scientific and Industrial Research

The stand of the Department of Scientific and Industrial Research, London, illustrated the work on engineering and marine problems undertaken by four of the Department's research establishments.

Pametrada showed a model of a steam turbine designed to have a maximum continuous rating of 8250 s.h.p. and to develop 7500 s.h.p. in normal service with steam conditions of 500 lb per square inch and 800 deg. Fah. The h.p. and l.p. turbines drive two pinions of double reduction gearing to give a propeller speed of 103 r.p.m. The h.p. ahead turbine is of multi-stage, high-efficiency impulse design and the h.p. astern stage is fitted on the h.p. ahead rotor overhung beyond the forward bearing and housed in a separate casing. Double casing construction has been adopted for the l.p. turbine, which is of mixed impulse reaction design and incorporates the l.p. astern turbine inside the l.p. ahead casing.

To measure the strains in the rotor set up by centrifugal stresses, an optical instrument, known as a rotor bore dilatometer, has been developed ; this instrument was exhibited on the stand. A cartridge containing three mirrors, two fixed and one free to tilt, is inserted into the rotor bore. This system of mirrors has the property of returning a beam of light parallel to itself, but when the third mirror tilts the returned light beam is no longer parallel to the ingoing beam and the effect of the degree of tilt, which is directly influenced by the bore diameter, is observed by a modified Hilger and Watts auto-collimator to give a measurement of the rotor bore strain.

An external dust control for pedestal grinders was shown by the British Cast Iron Research Association, Birmingham. The machine on the stand was a double-ended grinder with wheels of 24in diameter by 2in wide, running at a peripheral speed of 9000ft per minute, fitted with an exhaust system which brings the dust streams under control by surrounding the dust zone with high-velocity extraction air curtains external to the cowl. A top air extraction nozzle prevents dust from reaching the breathing level of the operator, and two side nozzles, one on each side of the wheel, provide extraction curtains to control the dust which may splay at right angles to the wheel. Also shown by the Association was a new method of clamping shell moulds, which consists of a mechanical clamp employing two sets of freely sliding pins carried in two rectangular hollow chambers. The pins are moved forward by compressed air and adjust themselves to the contours of the shells and in this way the mould area is supported uniformly and rigidly.

Illustrating some aspects of the work of the British Hydromechanics Research Association was a model showing how coal can be transported hydraulically. In addition to the fundamental problems there are practical ones involving the introduction of solids into a high-pressure water pipeline, and for this purpose the Association is developing a double-acting reciprocating feeder of which a transparent model was shown. The design incorporates a plunger containing two rectangular chambers which are automatically reversed at one end of the stroke so that one chamber lies beneath a hopper and is filled with coal, while the other chamber discharges its load of coal into one branch of the pipeline. Water pressures on the plunger are balanced so the only power required to reciprocate the plunger is that necessary to overcome friction ; but power is required to return to the high-pressure line the volume of water withdrawn by the plungers. The model, which has a ¾in bore pipe and a plunger of 1½in diameter, is capable of handling 20 cwt of coal and 400 gallons of water per hour, and a full-scale installation to handle 400 tons of coal per hour would require a pipe of between 14in to 16in diameter and an 18in feeder. Such a plant could handle coal up to 6in in size and for a lift of 2000ft about 1600 h.p. would be required.

Dobbie McInnes, Ltd.

A plotting table for recording input quantities in terms of rectangular co-ordinates was one of the instruments shown for the first time by Dobbie McInnes, Ltd., Glasgow, S.W.1. As illustrated in Fig. 33, this plotting table is a self-contained instrument measuring about 46in by 32in by 37in high.

It consists essentially of a pen (or other recording medium) driven by servo motors in two directions (rectangular x and y co-ordinates) simultaneously over a recording surface 30in by 18in. Input d.c. voltages representing the rectangular co-ordinates of the function that is to be recorded are fed into the plotting table. These x and y input voltages are amplified by direct-coupled valve amplifiers to operate the x and y servo drives which displace the pen in the x and y directions respectively. Associated with each of these drives there is a linear slide wire potentiometer which provides the required feed-back to complete the servo loop. In this way the locus of the pen, as expressed by the x and y co-ordinates at every instant, reproduces the characteristics of the input signals.

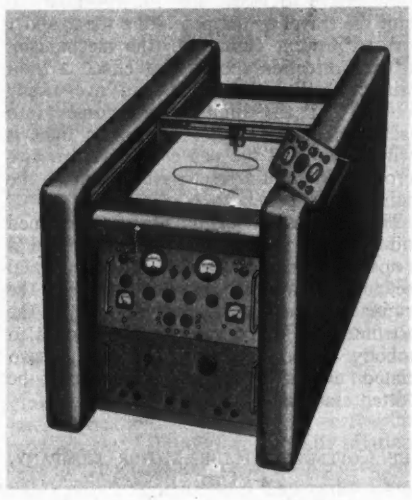


Fig. 33—Plotting Table—Dobbie McInnes

The pen is traversed by wire cables and pulleys along a gantry to give movement parallel to one co-ordinate axis, and the

gantry itself is similarly traversed to give movement along the other axis. The maximum writing speed of the plotting table in its present form is 15in per second and the dynamic accuracy is given as about 0·2 per cent at maximum travel in the y direction, with less than 5 deg. phase shift over the specified range. The frequency range of recording is between 0 and 0·2 c/s at full amplitude in the y direction. For either co-ordinate constant speeds between 0·1in and 5in per second can be selected independently. The range of input voltage swing for full-scale travel can be varied from 30V to 200V on the x axis and from 18V to 200V on the y axis. However, this is not the maximum sensitivity available and the voltage required can be reduced by modifying the circuit.

Various alternative recording methods are available—a ball-point pen on ordinary paper ; a metal stylus point on engine indicator metallic paper ; a heated stylus on heat-sensitive paper ; or an electrically energised stylus on "Teledeltos" paper. Timing signals, provided from the user's equipment, can, if required, be made to lift the pen and thereby produce a dotted line.

The instrument is designed for operation from a single-phase, 200/250V, 50 c/s supply and the necessary power packs are fitted in the base of the cabinet.

The plotting table is designed to be simple in operation. Drift is stated to be small and normally calibration is needed only once a day ; the instruments and controls required for this purpose are mounted on the main panel forming the front of the instrument. Apart from the daily calibration these controls are not required for normal operation of the machine. The main operational controls are grouped in a separate panel mounted above the plotting paper on the right-hand side of the table. These controls include start and stop push-buttons and speed setting controls.

Protective devices are incorporated to limit the travel of the pen along the x and y axes to prevent damage to the mechanism. In each direction there is, in effect, a limit switch, which is backed by an over-riding cut-out. If the limit switch comes into operation during a plot a warning light is switched on and the pen can be restored to zero by means of a reset push-button on the main control panel.

The instrument exhibited was designed and built for the Ministry of Supply and it is now being made available for commercial use. Modifications are contemplated to the original design to extend the scope of the instrument. For example, it is proposed to embody a second plotting pen so that two related events or characteristics can be plotted simultaneously.

The Coventry Victor Motor Company, Ltd.

Several diesel oil and petrol-driven engines of low power, including one, two and four-cylinder models and outboard engines, were shown by the Coventry Victor Motor Company, Ltd., Coventry. One of the principal exhibits was the "Neptune" water-cooled, horizontally opposed, four-cylinder, four-stroke marine petrol engine fitted with a reduction and reverse gearbox in unit construction, and illustrated in Fig. 34. This engine is available in three sizes, all of which have a stroke of 80mm, the cylinder diameters being 75mm, 80mm and 85mm, while the corresponding powers developed are 15/25 h.p., 18/28 h.p. and 20/33 h.p. at 1500 r.p.m. and 3000 r.p.m. respectively.

A silicon aluminium alloy has been used for the crankcase and close-grain, high-tensile cast iron for the cylinders, which are cast in pairs and have bores finished by a special process. The cylinder heads are of close-grain cylinder iron and the pistons, of heat-treated aluminium alloy, have two compression rings and one scraper ring, and are fitted with hardened, ground and lapped high-tensile steel floating gudgeon pins. Bronze bushes are fitted at the small ends

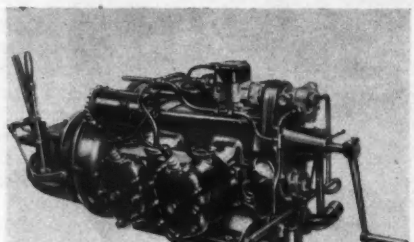


Fig. 34—"Neptune" Petrol Engine—Coventry Victor

of the 3 per cent nickel steel forged connecting-rods, which have shell steel-backed big-end bearings. The crankshaft is a nickel-chrome drop forging machined all over, heat-treated and carried in three steel-backed detachable shell bearings. Over the crankshaft is the chain-driven steel camshaft running in three bronze bearings. A gear oil pump driven off the crankshaft supplies oil under pressure to all bearings, and there is a gear pump for circulating cooling water.

B. Rhodes and Son, Ltd.

Two recently introduced designs of flow indicators for use in pipes carrying air, oil, steam, chemicals, &c., were shown in operation on the stand of B. Rhodes and Son, Ltd., Queen Street, Romford, Essex. One of these indicators, the spinner type, is illustrated in Fig. 35. The body of the instrument has glass side panels through which the spinner can clearly be seen. The

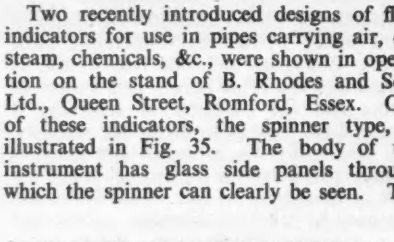


Fig. 35—Flow Indicator—Rhodes

spinner is mounted on a stainless steel axle on which it revolves freely with the flow of liquid. The body of the instrument is offset in the pipeline so that the liquid passing through has a clear, uninterrupted flow. In its passage the liquid impinges on the extremities of the spinner blades. The speed of spinner rotation increases with the speed of liquid flow and although, owing to the pipe being full, the liquid itself may appear to be still, the rotating spinner gives clear indication of the flow. Another flow indicator is of somewhat similar design, but in it the spinner is replaced by a counterbalanced flap, the arm of which is held up by liquid passing through. The spinners and flaps in both of these indicators are of a distinctive colour so that when the liquid flow is small or has ceased clear indication is given.

Lincoln Electric Company, Ltd.

Among the interesting developments shown by Lincoln Electric Company, Ltd., Welwyn Garden City, Herts, was the fully automatic submerged-arc welding process known as "Lincolnweld."

Briefly this process involves the deposition of granular flux on the joint to be welded, the depth of flux being sufficient to cover the weld metal, so that the arc is submerged. The flux is fed from a hopper through a flexible tube on to the joint. Bare "Lincolnweld" electrode is power fed from a wire reel into the blanket of flux, the rate of feed being automatically controlled to maintain the correct arc length. Arc control is effected by a circuit in parallel with the arc. This circuit consists essentially of the welding generator exciter in series with the wire feed motor and a rheostat. The arrangement provides correlation between the arc voltage, welding current and feed speed.

Direct current for welding is supplied from a Lincoln "Shield Arc" d.c. welding generator. The heat from the submerged arc melts the flux in the vicinity of the arc and the flux floats on the surface of the molten metal and then solidifies as a slag covering the weld. Because the arc and molten metal are shielded from the air by the flux it is possible to use high currents and achieve faster welding without sacrificing the quality of the weld.

The standard "Lincolnweld" head consists of the wire contact assembly, flux hopper and feed tube and the associated control station. Above this assembly is a platform which carries the electrode wire reel and the main control box which carries an ammeter, a voltmeter, a wire-inching rheostat and control knobs for adjusting the travel, welding current and voltage.

This equipment is suitable for applications in which the welding head remains stationary, while the work is rotated or moved by a suitable work-handling fixture. For other applications, where the work remains stationary, the "Lincolnweld" equipment can be supplied with a motor-driven carriage arranged to travel along a beam ; four gears are available to give a speed range from 6in to 8in per minute.

Sciaky Electric Welding Machines, Ltd.

One of the exhibits shown for the first time by Sciaky Electric Welding Machines, Ltd., Slough, Bucks, was the company's "SMC100" motor-driven stitch and pitch spot welding machine.

This equipment has a nominal rating of 100kVA and it embodies innovations such as automatic pressure control and stitch speed control. Welding speeds up to 120 spots per minute and electrode pressures up to 1750 lb per square inch are within its capacity. An air cylinder is fitted for electrode pressure compensation and for producing a retracting stroke. A fully synchronous ignitron panel, giving constant-current control and phase-shift heat control, is built into the machine.

These facilities make the "SMC100" welder specially useful for the welding of heat resistance steels as used in the jet engine industry.

(*To be continued*)

The British Association

No. III—(*Continued from page 364, September 18th*)

District Heating

A PAPER entitled "District Heating" was given by Mr. A. E. Margolis, of Messrs. Kennedy and Donkin, S.W.1, at a meeting of Section G (B) (Engineering) on Monday, September 7th.

Mr. Margolis, in presenting his paper, emphasised that Britain was particularly suited to district heating and said that if his ideas were accepted it would take the world a generation or two to bring them into operation. The paper opens with the following paragraphs :—

The term district heating is applied to a centralised supply of heat to a group of buildings or section of a town. The final aim of district heating is to extend the supply of heat to the area of a whole town, similar to the supply of cold water, gas or electricity. The general adoption of district heating will raise the standard of heating and living, improve the hygienic conditions and amenities and save great quantities of coal.

The development of district heating depends upon the fulfilment of two basic conditions : (*a*) reliability of service, and (*b*) economy of operation. (*a*) The reliability of district heating is greater than that of other services because the mains are provided with expansion devices and placed in conduits. An interruption of service by a fracture or dislocation of mains due to lack of expansion facilities or movement of the soil, as in the case of cold water or gas pipes, is out of the question. Moreover, an interruption of the supply of water, gas or electricity causes a great inconvenience or even a calamity, whereas an interruption of the heat supply for an hour or two hardly affects the consumer. In addition, any repairs of a district heating supply system, should they be necessary at all, can be carried out during the night because district heating is essentially a day-time service. (*b*) The economy of district heating depends mainly upon the saving of fuel. The advancement of district-heating engineering in recent years, particularly in regard to combined heat and power generation, has considerably increased the savings and thus widened the economic basis of district heating. Direct heat supply from boilers eliminates much of our present waste of fuel ; but only by co-ordination of heat and power generation on a scientific basis, utilising the high-temperature heat for power generation and the low-temperature heat for heating purposes, can the great waste both of domestic fuel and of that caused by condensing stations be completely eliminated. This double saving in fuel makes large-scale development of heat-electric generation and district heating economically possible, because the cost of electricity generation is reduced and the heat can be supplied at a lower cost (including capital charges) than by any conventional method of heating.

In reply to questions, Mr. Margolis said that the storage of hot water by an electrical system would require four times the capital expenditure that his system would for the same quantity of water. With regard to electric heating, the supply should be co-ordinated with district heating. Heat pumps could be used, but the efficiency and cost of the method gave rise to question. He had seen a plant at Zürich, but it could not be justified economically. At present the method was too expensive and required too much maintenance. Asked about the economic distance from a power station for a district heating system, Mr. Margolis said that it depended upon the quantity involved. With small use the range was very limited because of the cost of the piping and the heat losses. In Hamburg the supply was over a distance of 6 miles on Sundays, but not on weekdays because the load was then too high. Theoretically, the supply could be delivered for a distance of 10 miles or more, but it depended upon the quantity to be supplied.

Heating in Buildings

A paper entitled "The Measurement of the Efficiency of Heating in Buildings" was then given by Mr. A. T. Pickles, O.B.E., Physics Division, Building Research Station, Garston, Herts.

Mr. Pickles said that most of the known facts, as well as most of the possible opinions, concerning the efficient use of fuel in this country were given in the report of the Ridley Committee, and the subject was now so thorny and complex that no account of the general problem of fuel economy could usefully be given on a smaller scale than that of the report and its attached appendices. One important interest of the engineer and scientist lay in the reduction of the area of opinion and the increase in factual knowledge. That had been attempted in a series of detailed experimental researches on the heating of buildings carried out at the Building Research Station since 1946. Work on small houses was carried out in forty-four houses built on the station's experimental site at Abbots Langley, and it had subsequently been generalised by work in collaboration with local authorities and by survey techniques. Subsequent work had been concerned with the heating of schools and factories, and an experimental assessment of the efficiency of a small district heating plant for houses had been carried out. In all the work, the essential condition had been that the buildings should be normally occupied.

Mr. Pickles estimated that half the country's coal production was used for the heating of buildings, and he pointed out that while the national interest was the least possible use of fuel, for the consumer's interest, cost was the only criterion. The temperatures at which people ran their houses and the amount of hot water that they used was bound up with the costs, the marginal costs in particular, of the services.

The results which had been obtained related to the way in which the ordinary families lived in the typical small local authority houses built since the war, and similar results for normal use had been obtained in schools and factories. This had been achieved by the extensive use of recording instruments. In the experimental houses, the temperature in each room was continuously recorded by day and night for over four years in some instances by means of a system of multi-core cables connecting the thermometers in the houses to central recording stations. The ventilation rate was measured from outside the houses by the use of helium as a tracer gas, detection being carried out by thermal conductivity bridges. The heat intake was calculated in terms of the solid fuel delivered, and the electricity or gas was metered. The work had led to the rehabilitation of the open fire in an improved version and fitted with a back boiler as the recommended system for small houses.

Similar measuring techniques were used in factories and also in schools. By arrangement with the Hertfordshire County Council a new primary school near the station was designed with two classrooms heated by forced warm air, two by floor heating and two by conventional radiators, and the amount of heat used by the three kinds of heating equipment was measured in relation to the temperatures, temperature gradients, ventilation rates and air currents in the classrooms. The results showed a substantial fuel economy with the warm air method of heating in schools with conventional operation of the systems. However, they served to emphasise the essential feature of fuel economy, that the heat service must be related to the needs of the occupants. Schools were occupied only about 20 per cent of the time, and thus the economy with a very flexible system like warm air heating was readily understandable. Research was proceeding on control systems for radiator and floor heating systems, in order to increase their flexibility.

Similar work was now being undertaken by other authorities, and a great deal of practical experience had been accumulated during the post-war years. The possibilities of fuel saving in buildings were seen to be related to the needs and habits of the occupants and the use of the building. The various types of buildings, such as low-density housing, flats, offices, factories, schools and hospitals, were found to have special requirements in each case which were almost, if not equally, as important as the primary requirements of efficient combustion and good thermal insulation.

Mr. Pickles emphasised that the principal requirement was detailed analysis of existing schemes as a guide to practice, and it had to be borne in mind that, while one could write down the engineering equation of heat balance for small houses, they did not behave like that when people were in them. What limited heat usage and heat loss in small houses was the fact that people were in them controlling the heat used and did not wish to pay for a very great deal.

Wing-Commander T. R. Cave-Browne-Cave, C.B.E., said that the paper was an extraordinarily valuable one to designers and also to the general public in enabling them to appreciate the careful investigation which had been carried out and to understand quite simply what the general conclusions were. He gathered that air temperature was taken as the criterion of effectiveness of heating. He wondered whether that was correct. Surely what really mattered was the effective comfort of people occupying the space. Southampton University library had, for a certain reason, to be heated through the floor. With their feet on the warm floor the students found it to be very comfortable, yet they were very uncomfortable in the hall of residence, which was panel-heated from the ceiling. Measuring air temperature in the two places would not give anything representing the great difference in comfort between the two systems. In heating work on passenger service vehicles it had been found that a difference in temperature of 15 deg. between the inside and the outside was ample for passengers wearing the coats that they would have chosen for a particular day. The assessment of the effective comfort for classrooms and living rooms was much more

difficult because of the discomfort suffered mainly because feet got cold.

Mr. Pickles said that Wing-Commander Cave-Browne-Cave had most lucidly put the case for floor heating. He added that heat saving was a matter of common observation. It was difficult to conceive of a large experiment which would show a substantial saving of fuel. They had to ask themselves what possible experiment would translate a matter of common observation into a plain measurement of heat saving.

Wing-Commander Cave-Browne-Cave said that the comfort in the Southampton University library was achieved with an air temperature of 60 deg. because it had a warm floor, and he felt that if the air temperature in the building was maintained at 60 deg. by introducing warm air the effective comfort would be very much lower. The loss of heat from the building was presumably proportional to the difference in temperature inside and out.

Mr. Pickles said that it was not as simple as that. The occupancy of the library might be rather lower than 10 per cent of the university population. In those circumstances a more flexible kind of heating which did not keep the whole structure hot all the time might lead to a considerable saving. It depended upon what was required. Panel heating from floor and ceiling was probably good in a hospital because the patients were there all the time. Twenty per cent occupancy was a definite design factor to be taken into account in the case of schools.

Professor W. F. Cassie, King's College, Newcastle upon Tyne, asked about the effectiveness of glass wool insulation in roofs. He also said that he had been shocked to hear an official recommendation for an open coal fire with improved equipment and efficiency. The country had a serious atmospheric pollution problem, and to recommend the burning of coal in that manner seemed to be encouraging the *status quo*. The serious fogs and fatalities in London last winter were ample illustration of the effects of atmospheric pollution, not only because of the soot particles in the air but also because of the sulphurous fumes. Had that aspect been considered or was the recommendation based on the one matter of the cost to the consumer ?

Mr. Pickles said that glass wool insulation substantially increased thermal resistance. In Britain people did not keep bedrooms very hot and so there was not much heat to save, but most people who had glass wool insulation were very satisfied with it. The matter of atmospheric pollution was rather complex and he wondered whether the ordinary domestic consumer was not being blamed too much for it. There was no doubt that a great deal of atmospheric pollution must come from industry and from electricity generation. The recommendation had been made because they had to live in the present and no other method would have been suitable for the houses built. Their problem was whether they should make a half step forward to efficiency rather than wait until they had the complete answer, and he did not think it would have been economically possible to do anything else.

In reply to further questions, Mr. Pickles said that there would be considerable fuel saving in multi-storey schools. A reason for the large amount of glass in recent schools was that it was cheap, and it represented a balance which had been struck. Recent school building, principally of the single-storey type, had been chiefly of primary schools because of the increase in the birth-rate after the war. The secondary schools erected in the next two or three years would be multi-storey ones.

Calculating Machines

At a meeting of Sub-Section A (Mathematics), on Monday, September 7th, papers were presented by Professor L. Rosenhead, F.R.S., Head of the Department of Applied Mathematics, Liverpool University, entitled "Society and the Calculating Machine"; Dr. A. Fletcher, Senior Lecturer in Applied Mathematics, Liverpool University, entitled "Mathematical Tables, Past and Future"; and Mr. A. Young, Lecturer in Applied Mathematics, Liverpool University, entitled "The Use of Punched Cards in Science and Administration."

Professor Rosenhead said that machinery for calculation, in which public interest had been aroused by terms such as "mechanical brains" or "electronic brains" and statements that the devices "thought," "used judgment" and "played games," did not contain any new principles of design, but embodied the refinement and elaboration of known techniques. They were aids to computation.

The principal features of the most modern machines were : they were digital in that they carried out their operations on discrete objects which represented numbers ; they were fully automatic in that once the initial instructions had been formulated and programmed the machines carried out their tasks without further human intervention ; they were electronic, electronic valves being used in their design ; they carried out calculations with a speed and reliability quite impossible in human computers ; they were multi-purpose in that they could be used for the solution of a wide variety of mathematical problems ; where the machines appeared to think or to use judgment, the criteria for the judgment had to be thought out by the operators and embodied in the machines.

A review of the social, commercial, administrative and scientific needs of the present time showed that the desire for speed in computation was not just a passing whim. There was shown to be a need based on a realisation of what was happening in society. The ability to make the machines was a tribute to the skills of the mathematician, the engineer and the inventor. However, a healthy society must contain not only people of brilliant inventive minds but also those who had the wisdom to see the potentialities of those machines, to help in their development and to use them. Pure science provided the ideas, but in the main it was left to private commercial enterprise and the fighting services to develop and use them—about 125 years after an Englishman, Babbage, had laid down almost all the scientific and engineering principles which were involved.

Looking to the future, Professor Rosenhead visualised the creation of simpler, less expensive, machines ; a growing use of numerical analysis, as distinct from mathematical analysis, in the solution of problems of pure and applied science ; the solution of many problems of applied science hitherto considered to be impossible on account of the difficulty of the purely mathematical approach, or on account of the excessive labour involved in numerical solutions based on the use of human computers ; the revitalisation of many branches of applied science ; the development, in psychology and medicine, of a deeper understanding of certain aspects of the activity of the human brain ; and, last but not least, a greater interest in the development of automatic machinery for a wide variety of purposes.

Dr. A. Fletcher said that tables had improved greatly, in both fullness and accuracy, in the last fifty years, mainly through the development of calculating machines. Nevertheless, in most fields of mathematical tabulation there was still much work to be done. For instance, definitive source tables (error-free tables giving at least ten-figure values) of all six trigonometrical functions were available only in the traditional sexagesimal angular units (degrees, minutes and seconds). Source tables for trigonometrical functions of angles in other measures (degrees and decimals, grades, revolutions, radians, &c.) were not yet adequate, doubtless because of the dispersion of effort among so many systems.

In recent years automatic computing installations had begun to contribute copiously to mathematical table-making, as they could compute and print numerical values rapidly. It was a tremendous advance that the engineers had come to the rescue in that way and presented mathematicians with the means of making better tables at less cost in personal drudgery.

The number of mathematical tables extant probably considerably exceeded 5000 and was increasing by at least 100 each year. It did not, however, seem likely that ordinary printed mathematical tables would be superseded in the foreseeable future by automatic computing engines and tables stored, for example, on punched cards. Such equipment was invaluable when large pieces of systematic computation had to be done, such as the repetition a large number of times of a definite pattern of calculation, but not all computations made by scientists and technicians were of that kind.

Mr. A. Young said that the records of scientific research were so vast and were accumulating so rapidly that further progress was in danger of being delayed if scientists failed to solve the problem of making the results of research readily available. It was essentially a problem of documentation which had its counterpart in the spheres of industry and commerce. Punched card machine systems which were originally invented to meet the needs of the statistical analysis of census data were extensively developed because they were found to be capable of solving the problems of administration in large-scale accounting. Modern punched card equipment was limited in use only because many operations of an identical nature were required to be performed for economical use of the machines. Edge punched card indexes had been found to be admirably suited to the purposes of the bibliographical classification of research papers and similar tasks and went far towards solving many of the problems of scientific documentation.

In the field of scientific computation, special punched card machines were available which were more versatile than those yet in general commercial use.

(*To be continued*)

Drainage of Radioactive Materials.—A new method for dealing with the drainage and effluent of radioactive materials has been adopted in the laboratory of Hammersmith Hospital, London. The necessity for keeping these materials separate from other wastes means special containers, pipelines and pits for collecting them. To resist the effect of radioactive material upon this equipment a coating of synthetic rubber dough, which on drying becomes vulcanised, has been trowelled on to the storage pits and sumps. It is claimed that these coatings become waterproof without the need for heat, as the compound merely dries by loss of solvent. Research work is now being done by the Dunlop organisation to find out whether the dough, originally developed and used for radioactive material, can be applied in other directions.

The Third European Machine Tool Exhibition

No. II—(*Continued from page 362, September 18th.*)

SOME further exhibits seen at the Third European Machine Tool Exhibition at Brussels are described here.

Frondenberger Maschinen-und Apparatebau G.m.b.H.

The firm of Fröndenberger Maschinen- und Apparatebau Gesellschaft, of Fröndenberg on the Ruhr, which specialises in the production of keyway cutting machines, showed the largest machine it makes machining a keyway in a propeller. This machine which has a maximum length of stroke of about 55in is designed for large heavy work weighing up to some 30 tons.

The drive from the motor is transmitted through V belts to a reversing gear coupled to an electro-magnetic clutch, and a worm gear and pinion which engages with the inclined toothed rack in the vertical tool slide of the machine. The auxiliary feed and tool relieving drives are hydraulically operated and all controls are grouped at eye level at the front of the machine. The design and construction of this new machine is based upon the smaller machines with hydraulic and mechanical controls which are made by the firm.

Wagner and Co.

The large machines exhibited by Wagner and Co., of Dortmund, Germany, included a lathe designed to swing work weighing up to 25 tons and 26ft long. This machine has an infinitely variable range of spindle speeds between 1·25 and 200 r.p.m., and its saddle is fitted with a special screw-cutting unit with which threads up to 31½in long can be cut.

With this screw-cutting unit no orthodox lead-screw or feed shaft is used on the machine, but the makers have introduced what is termed an "electrical shaft." For the screw-cutting and longitudinal feed motions an asynchronous slipring machine, or control generator, is direct-coupled to the main headstock d.c. driving motor. This control generator is connected in parallel with a second asynchronous slipring motor arranged as a feed drive motor and built into the saddle of the lathe. The rotors of the two slipring machines are connected electrically and the stators of both are supplied from the a.c. mains. With this arrangement the two machines run in synchronism, the phase lag being the same for both rotors. The makers claim that with this saddle feed system there is no torsion or distortion to be taken into account as is the case with lathes fitted with long lead screws and feed shafts, and no feed gearboxes are required.

The machine exhibited had a centre height of 31½in and a similar lathe with a centre height of 40in and designed to swing components weighing up to 40 tons is illustrated in Fig. 5. This machine has spindle speeds ranging from 0·75 to 120 r.p.m. and for each spindle speed twenty-four sliding and surfacing feeds are available to each of the two saddles.

The equipment made by Wagner and Co. is handled in this country by Lerche Machine Tools, Ltd., Oakwellgate, Gateshead-on-Tyne.

Fritz Werner G.m.b.H.

A horizontal milling machine arranged for preselection of feeds and speeds made by Fritz Werner G.m.b.H., of Berlin, is designed to make full use of modern milling methods and cutters for the machining of materials ranging from aluminium alloys to hard nomic alloys. This machine, which is illustrated in Fig. 6, is handled in this country by the Rothwell Machine Tool Company, Ltd. It can be arranged for a variety of automatic cycles and normally at the commencement of the rapid return of the table the milling spindle is braked to avoid marking of the workpiece. A rise and fall device operating the knee incorporated in the machine is fully automatic and works in conjunction with the table traverse. It lowers the table prior to the rapid return and raises it to the exact operating height when the table has reached the starting position. This rise and fall mechanism can be push-button operated for milling both in longitudinal and transverse direction. When used in conjunction with the automatic table cycle fully continuous milling is carried out, as work can be loaded whilst the machine is cutting without the danger of the cutter fouling the work during the rapid return.

The machine has forty-two spindle speeds, from 16 to 1800 r.p.m., and fifty feeds from $\frac{1}{32}$in to 80in per minute are provided for all three directions. All feeds and speeds are preselected and feed rates can be changed whilst the machine is cutting. This change is controlled by a push button fitted to the knee and is effected through magnetic clutches. Illuminated windows fitted to the left-hand side of the machine indicate the spindle speed and feed which has been selected and also show the direction of rotation of spindle and direction of feed.

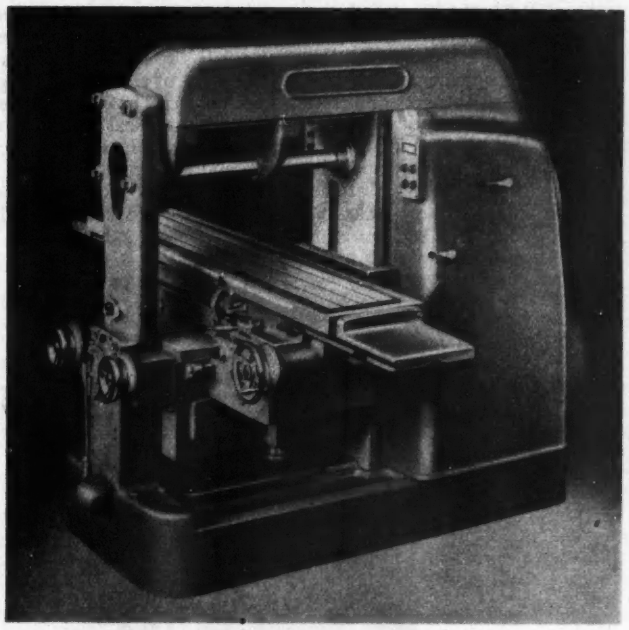


Fig. 6—Horizontal Milling Machine—Werner

A 40 h.p. motor is fitted as standard equipment and when using low spindle speeds the transmission automatically adjusts itself to the torque required. The two gearboxes for spindle speed change and feed change are self-contained units. In order to damp out vibration special automatically pressure lubricated spindle bearings are fitted. Hydraulic knee clamping takes place automatically and affects all the motions not actually in use at the time. When the machine is used in the tool-room an additional handwheel fitted to the table motion can be used for fine table adjustment in the longitudinal direction—the amount of movement being clearly visible on a large graduated dial.

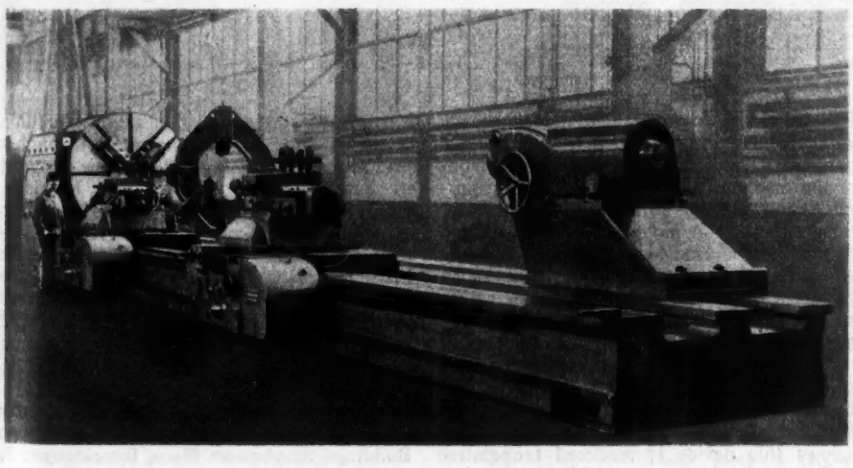


Fig. 5—Heavy Lathe—Wagner

L. Schuler A-G.

The group of presses demonstrated by L. Schuler A-G., of Göppingen-Württ, Germany, included an automatic transfer press which is made in capacities from 40 tons upwards.

The rigid main frame of this machine is an assembly of high-duty cast iron units comprising the main table, head and uprights within which a box frame ram slides on eight separately adjustable guides. The weight of the ram is balanced by four pneumatic cylinders and is driven through crankshafts at each end of the machine.

Material is fed from decoiling cradles in front of the uprights and first passes through a five-roller leveller before entering a precision roll feed. Between the two sets of feed rollers in the left upright of the machine is the first tool station. Blanks punched in this station are carried part of the way towards the second tool station by a slider. The blanks are then moved on by two reciprocating rails carrying gripper plates, which also carry out the transfer operations between the remaining tool stations of the press. These rails are actuated by a system of links and the length of feed can readily be adjusted in accordance with the distance between the tools. Each rail carries as many gripping jaws as there are tools. The shape of the jaws and the distances between them are made to suit the components and the respective centre distances of the tool stations. The rails are automatically brought together to close the jaws at the beginning of the forward motion in every operating cycle, and move automatically apart at the end of the forward feed. It is possible to set different amounts of opening for each of the two sets of jaws for the production of non-symmetrical components.

Each of the toolholders in the ram can be adjusted in height and the top toolholders are firmly locked in position by clamping plates. Every tool station in the ram, except the first, is provided with an ejector adjustable for height.

The 40-ton capacity press made by the firm can for certain purposes be fitted with a roll feed at each end. With this arrangement it is possible to work from both ends of the machine towards the centre and, if required, make two different components at the same time. If, for example, a press with thirteen tool stations is used the stations can be split in any way required with a certain number working from the right and the remainder from the left. For this purpose the feed rails are made in two parts, one sliding within the other and so designed that they can be locked together to work in unison or freed to work in opposite directions.

Fritz Studer

A group of grinding machines exhibited by Fritz Studer, of Glockenthal-Thun, Switzerland, included two models of an interesting design of profile grinding machine, the largest of which is illustrated in Fig. 7. With the use of a template this machine grinds profiles up to 12in long and 4·3in thick or up to 10in diameter. The grinding operation is fully automatic, the linear movements of a stylus-bar swivelling about its point being transmitted to the wheelhead through a pantograph, whilst its swivelling movements are transmitted through link-bars. The grinding wheel itself swivels about its cutting edge. The stylus bar has a slightly rounded tip and is carried along the contour of a suitably enlarged template.

The work holder slide is carried in long vertical guideways on one side of the machine and its stroke rate can be varied from eighteen to eighty strokes per minute in six steps. The grinding wheelhead is suspended from a bracket at the side of the machine and is free to swivel to any angle in accordance with movements transmitted from the stylus bar. The template table on the upper front of the machine is graduated for setting purposes and can be adjusted transversely or longitudinally. A hinged guide bar attached to this table is used for forming the grinding wheel to the shape of the stylus tip. When flat form tools with a clearance angle are to be ground the inclinable table holding the template is set at the appropriate angle.

A device for automatically feeding the stylus along the template can be set to give the required feed and is used in conjunction with adjustable stops. By loosening two screws this device is rendered inoperative and the stylus bar can be guided by hand in the usual way. Other attachments are provided for circular form grinding and the relief grinding of dies.

This company is represented by Sidney G. Jones, Ltd., 8, Balham Hill, London, S.W.12.

Deragne Freres

A precision machine for jig and production boring operations which is made by Déragne Frères, of Villeurbanne, France, is illustrated in Fig. 8. This machine has a boring capacity of approximately 1in to 8in and its spindle head has a vertical travel of about 18in. The table working surface is 53in long by 21in wide and the maximum setting distance between the spindle and the table is 31in. Precision scales and microscopes are used for co-ordinate setting of the table and this setting equipment, supplied by Optique et Précision de Levallers, is designed to make possible table settings to within 0·0004in.

The spindle is mounted in preloaded precision ball bearings and is driven through a unit giving a range of infinitely variable speeds from 150 to 5000 r.p.m. For heavy work the high-speed spindle is replaced by a long spindle fitted with a long sleeve. This spindle is used for boring holes from 2in to 8in diameter, to depths up to 16in.

The spindle head power feed motion drive is from a separate motor housed in the column of the machine, and is transmitted through a lead screw and floating nut which is designed to automatically take up any backlash. Feed rates from 0·0002in to 0·006in per spindle revolution are available. An independent motor supplies power for rapid spindle head power traversing purposes, and the spindle head can be set for an automatic cycle of rapid advance, cutting feed and rapid return. An automatic trip on the column can be set to control the depth of cut to precise limits.

The agent for the maker in this country is Stanley Howard, Ltd., 75/76, Exchange Buildings, Stephenson Place, Birmingham, 2.

(*To be continued*)

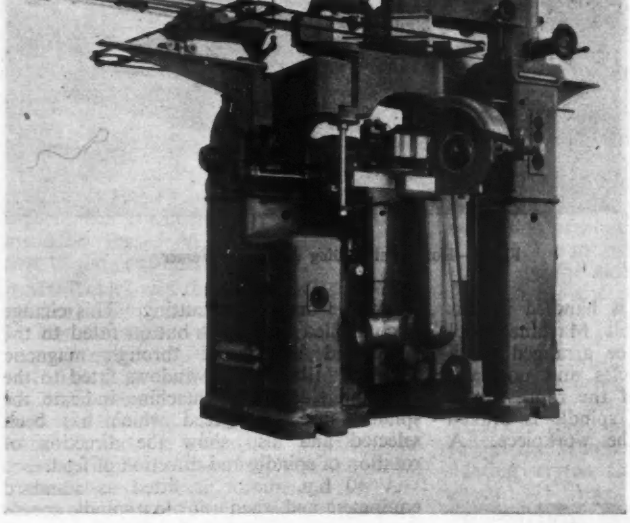


Fig. 7—Profile Grinding Machine—Studer

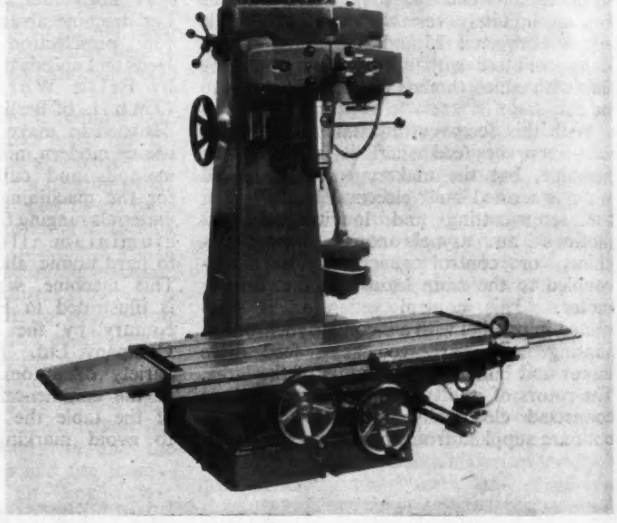


Fig. 8—Jig Boring Machine—Deragne

A General Purpose Electronic Analogue Computer

The electronic analogue computer described here is a general purpose equipment designed for economical quantity production by Short Brothers and Harland, Ltd. It is a differential analyser and its capacity is such that three similar computers coupled together should be capable of handling a general six-degrees-of-freedom problem. Some typical aircraft design applications are indicated in the article.

THE necessity for large-scale calculation in the design of aircraft has created an urgent demand for a computer which will solve simultaneous differential equations quickly, with reasonable accuracy, and present the results in a form convenient for observing the effects of varying the parameters of the system.

In other fields, particularly servo-mechanisms, a similar need exists, but it is not always possible to write down exact equations representing the behaviour of the system. The result is that equipment is often designed by trial and error methods—sometimes, as in the case of automatic pilots, under costly operating conditions. With this kind of problem the requirement is for a computer which will represent the transfer functions of the various parts of the equipment to enable the performance of the whole system to be studied. In addition, it is an advantage if actual components of a servo-mechanism can be coupled up to the computer for simulation purposes.

These different requirements are best satisfied by an electronic instrument operating on the analogue, rather than the digital principle. Although an analogue computer is not capable of the same degree of accuracy as a digital machine, most aerodynamic and servo problems only require answers correct to within a few per cent. A digital computer would probably be larger and more expensive for a given capacity and, besides, would give no insight into the

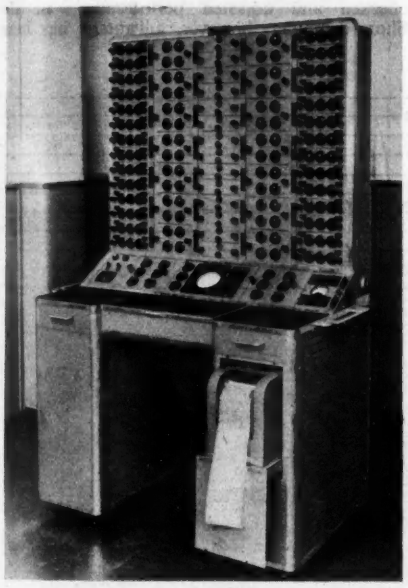


Fig. 1—Electronic Analogue Computer

physical behaviour of the system under investigation. One of the main advantages of the electronic analogue computer is that it is possible to run through in a few hours a range of solutions which might take days or weeks to compute on paper. An additional advantage is the ability to alter the effective time scale, so that events which actually occur over a period of several seconds or more may be compressed into one-tenth or one-hundredth of that time for more convenient observation.

Although several analogue computers have been constructed in this country during recent years, they have usually been designed as special-purpose instruments intended for only a limited range of problems and built individually. Their cost has therefore been high; and this fact, coupled with their large size, has put them beyond the reach of many potential users. With these considerations in mind, the research and development department of the Precision

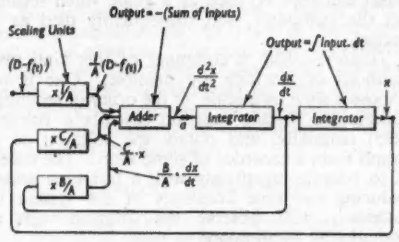


Fig. 2—Method of Solving Single Second-Order Differential Equation

Engineering Division of Short Brothers and Harland, Ltd., has evolved a compact general-purpose analogue computer (Fig. 1) designed for economical quantity production.

Principle of Operation

The principle of operation of the computer, which is a differential analyser, may be followed by considering a simple second order equation such as :—

$$A\frac{d^2x}{dt^2}+B\frac{dx}{dt}+Cx=0 \quad . \quad . \quad . \quad (1)$$

where A, B and C are constant coefficients. This equation may be rewritten as :—

$$\frac{d^2x}{dt^2}=-\left[\frac{B}{A}\frac{dx}{dt}+\frac{Cx}{A}\right] \quad . \quad . \quad . \quad (2)$$

If these terms are represented by time-variable voltages, and are all zero at $t=0$, then equation (2) can be satisfied by an electrical system arranged as in Fig. 2.

This network is obtained by assuming that d^2x/dt^2 exists at point "a"; producing dx/dt and x by successive integration; and then adding them, in the proportions indicated by the appropriate coefficients, using a device whose output is equal to the sum of its inputs but reversed in sign. This output must therefore be d^2x/dt^2.

The required solution will be the variation with time of the dependent variable x, or one of its derivatives, to a time-variable forcing function $f(t)$. This is obtained by injecting a suitable voltage transient as an additional input to the adder, and observing the response at the appropriate point.

If the equation includes a constant term it may be represented by

$$A\frac{d^2x}{dt^2}+B\frac{dx}{dt}+Cx+D=f(t)$$

or

$$\frac{d^2x}{dt^2}=-\left\{\frac{B}{A}\frac{dx}{dt}+\frac{C}{A}x+\frac{1}{A}[D-f(t)]\right\}.$$

For convenience, therefore, a constant term is generally included as part of the forcing function.

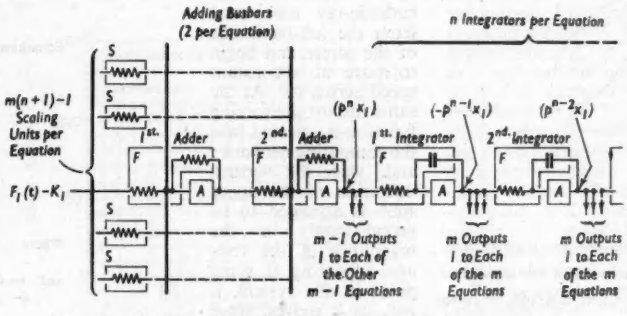
In a practical computer the integrators may also introduce a reversal of sign; and due account must be taken of this in setting up the problem.

In the examples given both the integrator coefficients are assumed to be unity. However, this is not essential; particularly when the computer is made to operate on a time scale other than unity, and it is often convenient to choose integrator coefficients which are some multiple or sub-multiple power of 10.

Basic Design

The first stage in the development of the computer was to decide on the size and capabilities of the instrument. This was approached from the point of view that a single unit should be large enough to cope with the day-to-day requirements of a design office or development laboratory, and that more difficult problems should be tackled by linking two or more computers together. The advantage of this arrangement is that, for a given outlay on computing equipment, a considerably greater volume of ordinary work can be handled, while still providing for the occasional more complicated problem. A number of typical problems were considered to settle this point. As a result, it was decided that one computer should be capable of solving three simultaneous linear second-order differential equations, i.e. a ternary flutter problem with all terms present.

For the solution of such problems only a few different kinds of computing element are needed. The essential elements are those which perform the operations of integration, addition and adjustment of scale. Now these facilities may either be provided as a number of single-purpose integrators, adders and scaling units, or as an equivalent number of general purpose amplifiers which may be associated with various passive networks to perform the same operations. Although, at first sight, the former arrangement seems more convenient, it leads to an uneconomic design because enough elements of each type must be provided to cope with any problem and therefore for most problems there will always be a considerable number of idle units.



Two adders are shown to permit sign reversal where required.
The above arrangement is repeated for each of the m—1 remaining equations.

Elements required for m equations of nth order (excluding ones for subsidiary use, e.g. forcing function generation) :

Amplifiers (A); $m(n+2)$ i.e. two adders plus n integrators per equation

Function Units (F), as for Amplifiers.

Scaling Units (S); $m^2(n+1)-m$ i.e. $m(n+1)-1$ per equation ;
[constant term and forcing function assumed combined and applied through a fixed resistance to adding busbar]

Fig. 3—Connections for Solution of Differential Equations

In the prototype of the Short computer the alternative principle was adopted, and three basic types of computing element provided. They are : (1) scaling units, which are essentially three-decade variable resistances; (2) function units, consisting of various resistance/capacitance networks, which may be selected with switches; and (3) amplifiers, consisting of high-gain, five-valve units which may be used in combination with the scaling and function units for addition, integration and all other linear operations in computation and simulation.

The way in which these units are interconnected for the solution of differential equations is shown in Fig. 3. A logical consideration of the interconnections required for the general case of *m* equations of *n*th order—

General Case of m Equations of nth Order

$$a_{11}p^n x_1 + b_{11}p^{n-1}x_1 + \cdots + a_{1n}p^n x_n + b_{1n}p^{n-1}x_n + \cdots + a_{1m}p^n x_m + b_{1m}p^{n-1}x_m + \cdots + K_1 = F_1(t)$$

$$a_{21}p^n x_1 + b_{21}p^{n-1}x_1 + \cdots + a_{2n}p^n x_n + b_{2n}p^{n-1}x_n + \cdots + a_{2m}p^n x_m + b_{2m}p^{n-1}x_m + \cdots + K_2 = F_2(t)$$

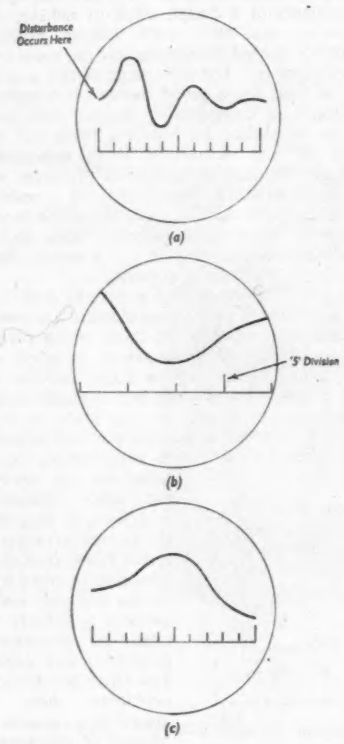
$$a_{m1}p^n x_1 + b_{m1}p^{n-1}x_1 + \cdots + a_{mn}p^n x_n + b_{mn}p^{n-1}x_n + \cdots + a_{mm}p^n x_m + b_{mn}p^{n-1}x_m + \cdots + K_m = F_m(t)$$

—leads to the construction of a table which indicates the scope of one or more computers having a given complement of computing units, assuming unrestricted interconnection. To meet the original specification with some reserve of capacity, fourteen amplifiers, fourteen function units and twenty-eight scaling units were provided in the prototype instrument. However, owing to the demand that three computers linked together should be capable of tackling a general six-degrees-of-freedom problem, and because of certain restrictions in the interconnections, the production version will be provided with eighteen amplifiers and a corresponding number of function and scaling units.

Description of Computer

The appearance of the prototype instrument is shown in Fig. 1. It is built in the form of a double-pedestal desk surmounted by a shallow rack, and is mounted on castors for ease of movement. The overall dimensions are only 5ft 9in high, 3ft 6in wide and 2ft 2in deep. All the sub-assemblies (such as the computing units) are designed to slide into the framework and be secured with quick-release fasteners, electrical contact being made automatically with suitable connectors.

The computer derives its power (approximately 1kW) from the normal mains supply via a number of power units which are fitted into the left-hand pedestal of the desk. The pen recorder, with its associated power unit and amplifier, is housed in the right-hand pedestal.



(*a*) Normal display showing disturbance and resulting oscillation of aircraft.
(*b*) Effect of sweep expansion for enlarging any position of trace.
(*c*) Effect of increasing integrator time constants or sweep speed.

Fig. 4—Timing Sequence

Set-Up Panel.—The computing units are interconnected for each problem by inserting small plugs into a "set-up panel" which is recessed into the top of the desk and covered by hinged flaps when not in use. This arrangement avoids the tangle of telephone plugs and cords which disfigures some computers. As a further simplification, blank charts are provided which can be marked with the positions of the plugs required for any problem. The chart can then be used as a guide when setting up the computer, and subsequently filed as a record.

Display.—With a computer of this kind two methods of working are possible. One is to choose a slow time scale, of the order of seconds, initiate the forcing function (usually a voltage step) manually, and obtain the solution as a graph from a recorder of some kind. The other is to operate repetitively with a fast time scale, reducing the time constants of the system if necessary, and observe the solution with a cathode-ray oscilloscope.

The second method is generally more convenient, since it gives a steady picture on a screen, and enables the operator to observe the result of changing the constants of a system immediately. However, it may not be satisfactory for simulation, because if actual components of a system are being used in a set-up they will generally have to work on a true time scale. Facilities have therefore been provided for both kinds of display by building a cathode-ray oscilloscope into the computer for normal use, and also arranging for a pen recorder to be fitted optionally. Thus an operator can set up a problem, determine the optimum constants by trial and error visually on a fast time-scale, and then turn to a slow-time scale to obtain a permanent record from the recorder.

Timing.—For repetitive operation the timing sequence is as follows:—

Each cycle of operation is divided into two approximately equal intervals. At the beginning of each cycle the two spots of the double-beam cathode-ray tube start from the left-hand side of the screen and begin to move at a constant speed across it. At the same instant the forcing function is injected into the computing network; and, since the vertical deflection of the upper spot is arranged to be proportional to the magnitude of the voltage appearing at some point in the system, it will, as it moves, trace out the time graph of the quantity represented by this voltage, which is the required solution, (Fig. 4*a*.).

The lower spot always moves horizontally in synchronism with the upper, but its vertical movement is normally controlled by a timing circuit so that a series of marks is produced which divides the trace into ten equal sections. The "0," "5," and "10" marks are accentuated and the trace has the appearance of a luminous scale below the actual solution. In this way the horizontal ordinates of a solution may be read off without the use of a physical scale or graticule. Alternatively, the lower spot may be used to display any other term in the system simultaneously with that shown by the upper trace.

At the end of the first half of each cycle, when the two spots have reached the right-hand side of the screen, a system of relays (one for each amplifier) restores the quiescent condition, and, during the second half of the cycle, corrects any drift in the amplifiers. While this is occurring the spots are extinguished.

The sweep speed may be set to any of the following values :—

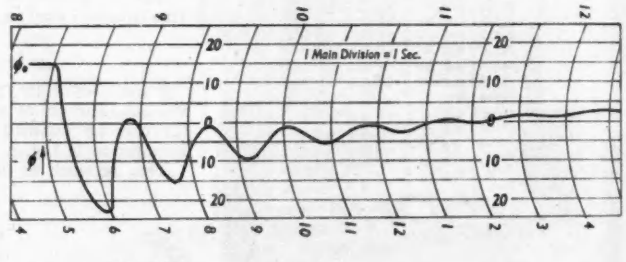
Sweep duration	Corresponding repetition rate
30 milli-secs	15 sweeps/sec. (approx.)
100 milli-secs	5 sweeps/sec
300 milli-secs	3 sweeps in 2 secs (approx.)
1 second	1 sweep in 2 secs

The effect of turning the speed control to a shorter sweep duration will be to expand the trace, so that only the initial portion of the solution is shown, but to a larger horizontal scale. The same effect can, of course, be produced by leaving the sweep speed unchanged, and reducing the coefficients of all the integrators (Fig. 4*c*). A sweep expansion control is also provided to enable an enlarged view of any part of the solution to be obtained (Fig. 4*b*).

In practice it will probably be found that a moderately high repetition rate is most convenient for general work. However, if it is desired to obtain a record of the solution on the pen recorder, the timing system may be switched off, the integrator coefficients set to give a solution lasting several seconds, and the forcing function applied by the manual operation of a switch.

The normal forcing function, which is generated internally by the computer, is a voltage step whose amplitude may be adjusted on the control panel. Alternatively any other forcing function, such as a sine wave, may be fed into the computer from an external source via the sockets provided.

Drift Correction and Clamping.—Two other important characteristics of the instrument are the incorporation of "drift correction" and "clamping." All d.c. amplifiers are prone to drift, i.e. a voltage is liable to appear across the output terminals when the input is zero, and in many computers the amplifiers must be checked and adjusted periodically. In the Short computer, however, advantage has been taken of the repetitive nature of the computing cycle by arranging for correction to be applied automatically during the quiescent interval between successive solutions.



Equations :

$$\frac{dx}{dt} - y_v x + \mu_0 z - \mu_0 k\phi = 0$$

$$-\frac{l_v}{i'_A}x + \frac{dy}{dt} - \frac{l_p}{i'_A}y - \frac{E}{A}\frac{dz}{dt} - \frac{l_r}{i'_A}z = 0$$

$$-\frac{n_v}{i'_0}x - \frac{E}{C}\frac{dy}{dt} - \frac{n_p}{i'_0}y + \frac{dz}{dt} - \frac{n_r}{i'_0}z = 0$$

$$-y + \frac{d\phi}{dt} = 0$$

Where $x \equiv \frac{\mu_0 v}{V}$; $y \equiv \frac{\mu_0 pb}{2V}$; $z \equiv \frac{\mu_0 rb}{2V}$

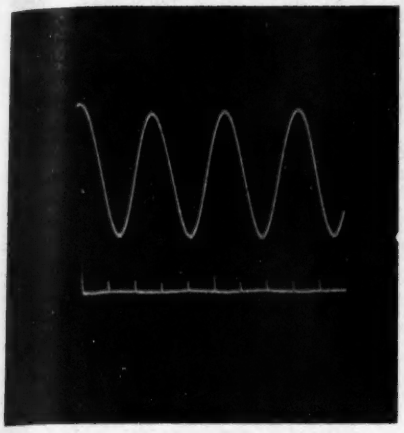
and v = sideslip velocity, p = rate of roll, ϕ = angle of bank, r = rate of yaw

Fig. 5—Lateral Dynamic Stability Problem

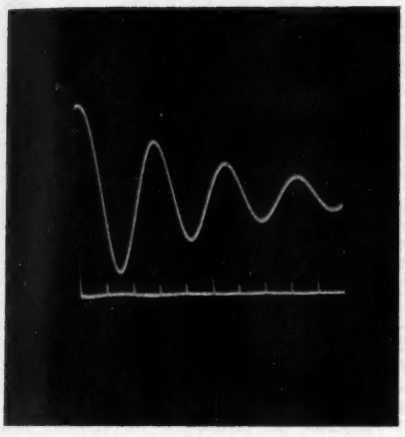
The principle of the system employed is to provide a capacitor, in series with each amplifier, arranged to be switched by a relay at the start and finish of each sweep. During the quiescent period each capacitor becomes charged to the drift voltage of its associated amplifier, and then at the beginning of each sweep it is switched so as to be in series with the amplifier. The combination of capacitor and amplifier may then be regarded as a drift-free amplifier for as long

as the capacitor retains its charge, provided the drift itself is not changing rapidly.

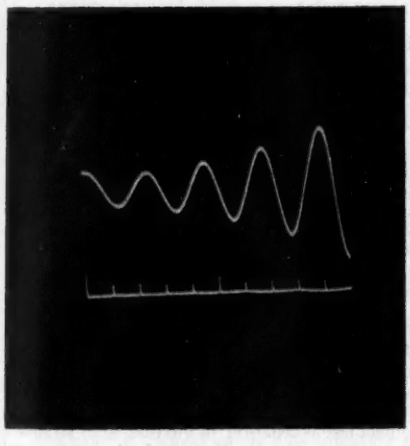
This system requires one relay for each computing amplifier and all the relays are driven synchronously by the timing circuit. An additional advantage of the scheme is that the relays can also be arranged to "clamp" the computing system at the end of each sweep, thus enabling the computer to cope with divergent solutions or unstable systems. Without clamping it would be impossible to obtain repetitive solutions of such problems.



(1) Critical stability.



(2) System just stable.



(3) System just unstable.

Fig. 6—Ternary Flutter Conditions

Operation

It is thought that the persons most likely to use the instrument for computation will be physics or mathematics graduates who will be fully capable of formulating the problems presented to it. Such users need not have any electrical knowledge, although it may help in planning the set-up for the most economical use of the computing elements if the operator has some knowledge of the processes involved. Servo engineers should have no difficulty in applying the computer to their problems, and in connecting it up with the various external systems.

The procedure is that the system, or equations, are reduced to a block diagram of the computing elements involved, using one of the record charts already mentioned, and the corresponding plug positions and dial settings marked on the diagrams provided. The setting-up of the computer, once the problem has been planned in this way, is very simple, and may be left to a semi-qualified assistant.

Having established the problem, it only remains to select the desired time scale and forcing function, and arrange for the required variable to be displayed on the screen. For a rough record the solution may be traced in pencil on a roll of "Kodatrace" film contained in a cassette adjacent to the screen. For more accurate results the pen recorder may be used, provided the integrator coefficients are adjusted to give a solution whose significant frequencies are within the range of the recorder.

Typical Applications

The examples given in Figs. 5, 6, 7 and 8 are typical of three different kinds of problem which can be dealt with by the computer.

Fig. 5 concerns the lateral dynamic stability of an aircraft, the required solution being a curve showing the variation of bank angle with time after a sudden (step) disturbance. In this particular case the frequency of the damped oscillation was calculated to be 0·62 c/s with a damping factor of 0·36; while the values obtained from the pen recording were 0·61 c/s and 0·33.

Figs. 6 and 7 show the application of the computer to a ternary flutter. The "answer" in this case is not the trace observed on the screen, but a curve showing the boundary between stability and instability in terms of the critical air speeds corresponding to given values of mass balance of a control surface. This curve was obtained by interpolation after measuring the increment or decrement of the amplitude of oscillation on the screen at a number of points selected to lie on either side of the probable region of the curve. The calculated curve is also shown for comparison, and it will be seen that the largest discrepancies occur in the region of the "nose" and amount to some 3 per cent of the corresponding value of mass balance. As a further indication of accuracy, the frequency of oscillation of the system for 20 per cent mass balance was measured as 9·6 c/s and subsequently calculated to be 9·8 c/s.

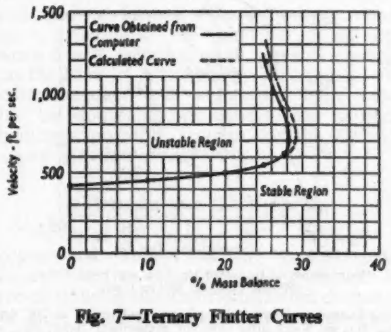


Fig. 7—Ternary Flutter Curves

Fig. 8 illustrates the use of the computer for servo simulation. In this example the servomechanism is a simple second-order position-control system, such as an aircraft control, and the object is to determine the gain required in the electronic amplifier to give the optimum amount of damping. The three recordings show conditions of excessive under and over-damping, and also the ideal setting.

Further Development

In its present form the computer will only deal with linear systems which are initially in a quiescent condition. However, several additional kinds of computing element now under development, particularly a non-linear function generator and a multiplier, will remove these restrictions and extend the scope of the instrument to problems that are not amenable to calculation by normal paper methods. The function generator, for example, will permit the investigation of the effects of such components as non-linear hydraulic valves in a servo system. It is also intended to make provision for the introduction of "initial conditions" so that studies may be made of the effect of applying the forcing function to a system which is already in a predetermined state of disturbance. For these reasons the production version of the computer will have a modified panel layout which will enable these additional computing elements to be interchanged with the basic units as optional facilities.

The equipment described here was developed and made by the Precision Engineering Division of Short Brothers and Harland, Ltd., Belfast.

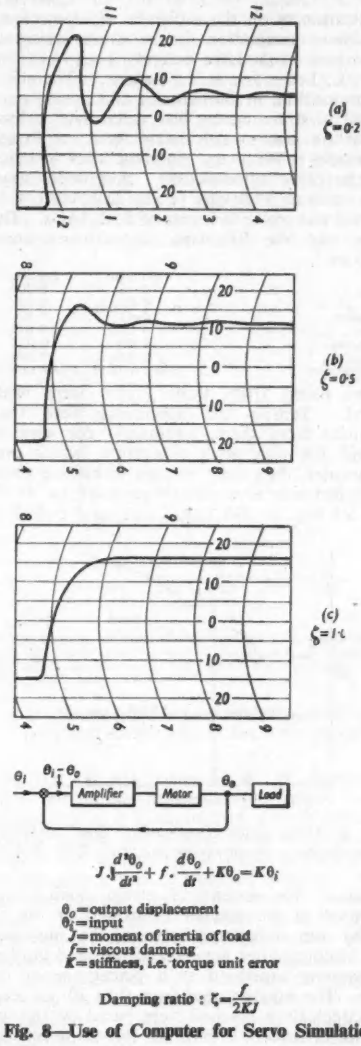


Fig. 8—Use of Computer for Servo Simulation

Symposium on Cathodic Protection.—A symposium on "Cathodic Protection" will be held at the Institution of Electrical Engineers, Savoy Place, London, W.C.2, on Friday, November 13th, beginning at 9.45 a.m., and finishing at 5.30 p.m. Seven papers will be presented embodying experience gained in various parts of the world with the protection of ships, underground pipe, storage tanks and other structures used in contact with water or soil. Cathodic protection is a method which has been energetically developed during the last few years, but has not hitherto had full public discussion in this country. The corrosion group of the Society of Chemical Industry is organising the symposium. It is understood that preprints of the papers will be available before the meeting.

Metallurgical Topics

Influence of Aluminium on Strain Ageing

EXPERIMENTS on the influence of aluminium- and silicon-deoxidation on the strain ageing of low-carbon steels have recently been reported by W. C. Leslie and R. L. Rickett.[1] The effect of composition, heat-treatment and ageing conditions on strain ageing was determined. Two low-carbon open-hearth heats were employed, one made to ordinary rimming steel practice and the other silicon-killed. A graded series of aluminium additions (1 lb, 2 lb, and 4 lb per ton) was made to ingots of both heats. The ingots had the following approximate compositions :—

	Per cent		Per cent
Carbon	0·10	...	0·20
Silicon	0·01	...	0·19
Manganese	0·42	...	0·82
Sulphur...	0·025	...	0·019
Phosphorus	0·011	...	0·011
Nitrogen	0·004	...	0·006
With aluminium	0·001 to 0·15	...	0·004 to 0·17

Bars rolled from these ingots were heat-treated. Tensile test specimens were then machined from them, strained 4 per cent or through the yield-point elongation, which ever was greater, then aged, usually in boiling water but sometimes at room temperature or at 67 deg., 93 deg. or 149 deg. Cent., and pulled to

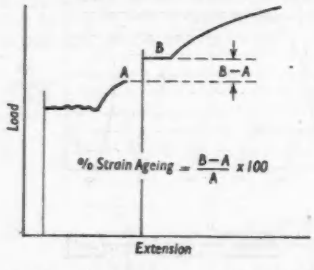


Fig. 1—Stress-Strain Diagram of Steel Showing Strain Ageing. Strain-ageing per cent=100 (B-A)/A.

fracture. The extent of strain ageing was measured in the manner illustrated in Fig. 1, i.e. by the difference between the increased yield strength after ageing and the load applied in straining expressed as a percentage of the latter. The values varied from 0 to 20 per cent. The conclusions reached were based on the use of this criterion ; and, as the authors very rightly point out, caution should be exercised in predicting results to be expected by the use of other measures of strain ageing, such as behaviour in the notched-bar impact test.

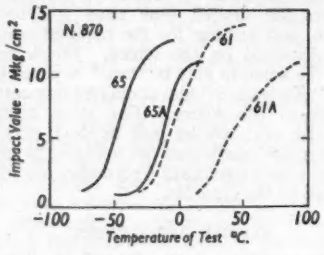
The principal conclusions reached by Leslie and Rickett were as follows :—

(1) Strain ageing of commercial steels is primarily due to nitrogen in solution in the ferrite ; deoxidation with silicon or aluminium affects strain ageing principally through the formation of nitrides and the removal of nitrogen from solution in ferrite. Carbon is a secondary cause of strain ageing and for this reason aluminium or silicon-killed steels cannot be completely non-ageing under all conditions. When high ageing temperatures are used, carbon will cause strain ageing even in steels completely killed with aluminium and silicon. To produce a steel which will show no strain ageing effects would require the addition of elements which reduce the solubility of both carbon and nitrogen in ferrite to a very low level.

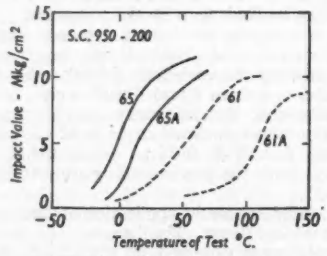
(2) Strain ageing of killed steels is governed by previous heat-treatment. The heat-treatments which reduce subsequent strain ageing are those which promote complete precipitation of nitrides. For aluminium-killed or aluminium-silicon-killed steels, slow cooling from the hot-rolling temperature is effective. For silicon-killed steels, extended treatment in the neighbourhood of 1100 deg. Fah. (593 deg. Cent.) is required, preferably followed by slow cooling. Conversely, killed steels can be made susceptible to strain ageing by rapid cooling which retains nitrogen and carbon in solution in the ferrite. The usual types of rimmed steel strain age regardless of heat-treatment because they do not contain elements which form stable carbides or nitrides.

(3) To reduce strain ageing of commercial steels to a low level, it is necessary to reduce the nitrogen in solution in ferrite to a very low concentration in the neighbourhood of 0·0001 per cent.

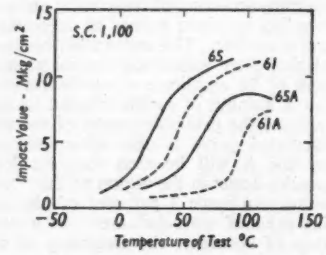
(4) Nitrogen is more effective than carbon in producing strain ageing because of its greater solubility in ferrite at low temperatures. When the solubility of carbon in ferrite is increased by



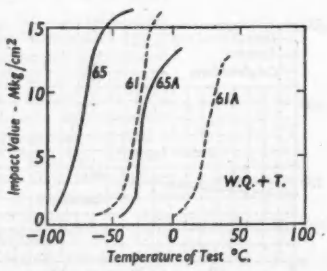
Normalised at 870 deg. Cent.



Furnace cooled from 950 deg. Cent. to 200 deg. Cent.



Furnace cooled from 1100 deg. Cent.



Water-quenched from 900 deg. Cent and tempered at 650 deg. Cent. for half an hour.

The steels were strained 10 per cent and heated at 200 deg. Cent. for six hours after different preliminary treatments, as shown, and then gave the curves marked *A*.

Figs. 2 to 5—Effect of Temperature on the Impact Value of 0·15 per cent Carbon Steels No. 61 Without Aluminium and No. 65 With Aluminium (Josefsson and Nygren)

high ageing temperatures, strain ageing is produced even when nitrogen has been completely removed from solution.

(5) Strain ageing may be reduced by deoxidation with aluminium or silicon, followed by the proper heat treatment. Because of the more rapid formation of aluminium nitride (AlN) and its greater range of stability as compared with silicon nitride (Si_3N_4), deoxidation with aluminium is more effective in reducing strain ageing than deoxidation with silicon. The authors add that, for reasons which are not entirely clear, deoxidation with silicon and aluminium is much more effective in preventing strain ageing than deoxidation with either alone.

In the conclusions of Leslie and Rickett recorded above there is to be found much which is in agreement with the findings of other investigators, especially those who were concerned with the measurement of strain-age-hardening as shown by tensile tests. For example, thorough deoxidation has for many years been recognised as a means of removing the tendency to strain ageing, but the strain age hardening of aluminium-killed low-carbon steel observed by C. A. Edwards, D. L. Phillips and H. N. Jones (1940) is held by Leslie and Rickett to be due to carbon, the effect of which, they say, is brought out by the higher ageing temperature, 250 deg. Cent. In their view, oxygen was eliminated, nitrogen was combined as aluminium nitride by the furnace cooling from 950 deg. Cent. but the carbon was still free to cause strain ageing if the ageing temperature was sufficiently high. They mention that an aluminium-silicon-killed steel, strained 4 per cent, showed little signs of strain ageing when aged at 100 deg. Cent. but much more when aged at 250 deg. Cent.

Davenport and Bain (1935) thought that oxygen was the principal element which caused strain age hardening ; but others, who also advocated thorough deoxidation, recognised that removal of oxygen was not the only function of deoxidising agents added to steel. These additions may at the same time affect the nitrogen content, modify the solubility of carbon and of nitrogen in the ferrite and exert a refining influence on grain size. German investigators, in particular, have concluded, like the present authors, that nitrogen is the principal element responsible for strain age hardening and that, while carbon may have a slight effect, oxygen has none. The fact that mild steel can be made non-ageing without being killed, by the addition of vanadium (as claimed by S. Epstein[3] and recently confirmed by W. R. D. Jones and G. Coombes[3]) lends further support to the idea that oxygen is ineffective and that nitrogen is the element mainly responsible for strain ageing.

There is agreement also on the importance of previous heat-treatment of the steel, and Leslie and Rickett quote several authorities who advocate annealing at about 650 deg. Cent. followed by slow cooling. For example, C. R. Felmley, C. E. Hartbower and W. S. Pellini[4] found that quenching from 650 deg. Cent. enhanced ageing tendencies regardless of steel deoxidation practice. Quickly cooled aluminium-killed steels developed strong ageing characteristics which were absent in the slowly cooled material. Possibly complications due to quench-ageing superimposed on strain-ageing should be taken into account in interpreting these results.

When it comes to laying down the most suitable treatment for avoiding the effects of ageing, the need (at least in the present state of knowledge) of distinguishing between strain-age-hardening and strain-age-embrittlement becomes evident. B. D. Enlund[5], using the Charpy impact test as criterion, found that, after straining and ageing, normalised steels, both rimmed and aluminium-killed, gave good impact figures, but that the rimmed steel which had been slowly cooled was embrittled by straining and ageing whereas the slowly cooled aluminium-killed steel retained a good impact figure. As a result of an extensive series of tests, B. D. Enlund recommended that a quenching and tempering treatment should be given to mild steels to minimise embrittlement due to strain ageing. This treatment is in marked contrast to the preliminary slow cooling recommended by Leslie and Rickett as a precaution against strain age hardening, and the discrepancy shows the danger of comparing results obtained by the use of different

criteria of strain ageing. Leslie and Rickett express the view that a determination of the shift of the transition temperature due to ageing would have been more illuminating; and, although Enlund's original paper contained some tests at temperatures from —40 to +120 deg. Cent., more recent work on these lines has been published in Sweden.

The superior notched-bar impact properties of aluminium-killed steel in the strain-aged condition have again been placed on record by A. Josefsson and E. Nygren[6]. They have determined the effect of aluminium on the tendency to brittle fracture and on the grain size of three series of mild steels, electrically melted, with increasing aluminium additions. The preliminary treatments were normalising, furnace cooling or water-quenching and tempering. The steels were tested after being strained 10 per cent and heated at 200 deg. Cent. for six hours. Charpy tests were made between —80 and +100 deg. Cent., and the transition temperature of tough to brittle fracture served as the criterion of tendency to embrittlement. Curves for tests on steels Nos. 61 and 65 (carbon 0·15, phosphorus 0·015, nitrogen 0·007 per cent with aluminium additions to No. 65) are reproduced in Figs. 2–5 to illustrate the results. The lowest transition temperatures were shown by the water-quenched and tempered material. The collection of curves given in the paper indicates that aluminium in appropriate amounts lowers the transition temperature but that straining and ageing raise the transition temperature whatever may have been the initial condition of the steel. The further observation was made that even when the grain size had apparently become constant further addition of aluminium again lowered the transition temperature. The effect on transition temperature continued up to the highest aluminium content investigated (giving about 0·3 per cent acid soluble aluminium) which was substantially higher than that required for fixing the nitrogen in the steel.

It seems unlikely that the action of aluminium is fundamentally different in strain-age-hardening and strain-age-embrittlement. The difficulty of extending conclusions based on tensile tests to cover behaviour in the notched-bar impact test may arise from the greater sensitivity of the impact test to grain size and other microstructural changes.

REFERENCES

[1] *Journal of Metals*, August, 1953, page 1021.
[2] See THE ENGINEER, September 29, 1950, page 324.
[3] *Journal of the Iron and Steel Institute*, May, 1953, page 9.
[4] *Welding Journal*, September, 1951, Vol. 30, page 451s.
[5] See THE ENGINEER, October 31, 1947, page 412.
[6] *Jernkontorets Annaler*, March, 1953, Vol. 137, page 69.

Diffusion of Hydrogen in Cold-Worked Steel

THE possibly detrimental effects of hydrogen on steels subjected to a pickling process are widely recognised. Apart from an embrittling effect which can be removed by degassing at about 100 deg. Cent., there may be permanent damage in the form of blisters due to the pressure of molecular hydrogen which causes rupture of the steel. Diffusion of atomic hydrogen proceeds rapidly, but at any discontinuity in the internal structure of the steel molecular hydrogen is formed; this does not diffuse and may therefore build up a high pressure. These effects may be intensified if the steel is cathodically charged with hydrogen, and for the purposes of study this method of introducing hydrogen is usually employed.

H. Schumann and F. Erdmann-Jesnitzer* have investigated the manner in which the diffusion of hydrogen is influenced by the condition of a steel containing carbon 0·09, silicon 0·05, manganese 0·36, phosphorus 0·01 and sulphur 0·03 per cent in the form of thin sheet. By cathodic gassing of small specimens of this sheet in a sulphuric acid electrolyte and measuring volumetrically the amount of hydrogen which penetrated in a given time, the influence of up to 90 per cent cold deformation with subsequent reheating at various temperatures up to 900 deg. Cent. was determined. It was thus established that by a small amount of plastic deformation, up to about 15 per cent, the rate of diffusion of hydrogen was slightly raised, but that it diminished rapidly when the plastic deformation exceeded about 30 per cent (Fig. 1). Softening

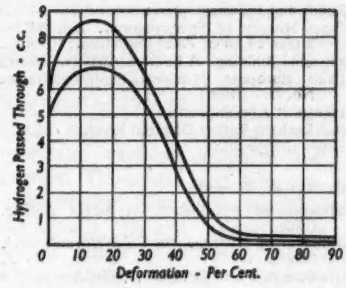


Fig. 1—Hydrogen Penetration (Upper and Lower Limits) in Relation to the Degree of Cold Work of Low-Carbon Steel Sheet (Schumann and Erdmann-Jesnitzer)

of the cold-worked steel tended to restore the rate of diffusion to its original value. By tests on the specimens after they had been cold-worked and subsequently annealed it was shown that the increase in the rate of diffusion had already set in after crystal recovery (i.e. atomic rearrangement of restricted range) had taken place, but before there was much fall in hardness. At the recrystallisation temperature, the diffusion rate continued to increase rapidly. Diffusion rate and hardness are shown in Fig. 2. The

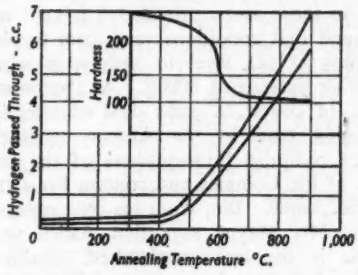


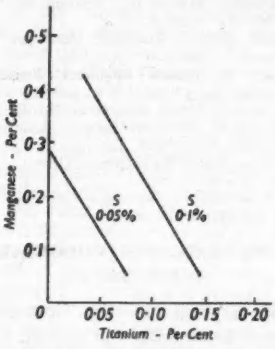
Fig. 2—Hydrogen Penetration of Low-Carbon Steel Sheet Cold Worked 90 per Cent and Annealed, and the Effect of the Annealing on Hardness (Schumann and Erdmann-Jesnitzer)

interesting observation was made that the number and size of the blisters produced, as a result of the gassing, on the surface of the steel sheet was dependent on the previous treatment of the material and varied inversely as the magnitude of the observed diffusion rate, indicating that there was an increase in the number of lattice imperfections or centres at which molecular hydrogen was formed. The authors put forward an explanation of the behaviour of the cold-worked and annealed steels towards hydrogen on the basis of lattice-energy conceptions. The more frequent and widespread opportunities for the conversion of atomic into molecular hydrogen probably account for the diffusion-arresting action of cold work.

Titanium as a Desulphuriser

THE value of titanium as a scavenger for oxygen and nitrogen has long been recognised. It ranks next to aluminium as a deoxidiser and the deoxidising and denitriding action of titanium in steel is effective in controlling strain-age-embrittlement. It has also proved to have been a valuable addition to steel for other purposes because of the readiness with which it forms a stable carbide. Apart from its use to combat weld decay in stainless steels, it has found wide application in welding rods. Its use as a desulphuriser is not so well known, but has been the subject of some work by J. D. Roach and R. S. Stewart.[1] Titanium reacts with oxygen in preference to sulphur so that its addition results in a fully deoxidised and killed steel. It is impossible to use titanium and still have a rimming steel; it therefore acts as a desulphuriser only in killed steels.

Forty-eight 30 lb H.F. silicon-killed ingots containing varying amounts of titanium, manganese and sulphur were made by Roach and Stewart and were tested for hot shortness. A hot-upsetting test was found to be too insensitive and hot-rolling tests at 1288 deg. Cent. were adopted with a finishing temperature of 927 deg. Cent. The 2½in square ingots were reduced in thickness to 1in in nine passes. Cracking indicated hot shortness, and its severity was judged from the number of passes or reduction of thickness undergone without cracking. These rolling tests showed that with 0·05 per cent sulphur cracking occurred if the manganese content was below 0·27 per cent with no titanium, or if the titanium content was below 0·075 per cent with 0·05 per cent manganese present as a residual element. Thus three parts of manganese were replaced by one part of titanium. There was a linear relation between titanium and manganese for this and other sulphur contents



The diagram has been slightly modified as it was inconsistent with the text in ignoring residual manganese. Compositions to the left of the line indicating sulphur content cracked badly; those to the right of the line rolled satisfactorily.

Fig. 1—Minimum Amounts of Manganese and Titanium to Prevent Red-Shortness (Roach and Stewart)

(Fig. 1). It was shown by W. W. Austin[2] that both zirconium and titanium might replace manganese as a desulphuriser, though (as judged by the rather severe conditions of a hot-bend impact test) he gave equal weight to the influence of manganese and of titanium as shown by the formula Mn per cent+Ti per cent=6 times S per cent. The relationship established by Roach and Stewart gives the titanium content at least three times the weight of the manganese. They do not suggest that the replacement of manganese by titanium is economically desirable. In normal circumstances such replacement, though technically possible, would not be practicable on account of the cost; but with the possibility of manganese shortage in mind they claim in the title of their paper, that "In Case of Emergency, Titanium Can Replace Manganese for Sulphur Control of Steel."

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[1] *Iron Age*, June 4, 1953, page 150.
[2] *Steel*, November 5, 1951, page 110.

NATIONAL SMOKE ABATEMENT CONFERENCE.—The twentieth annual conference of the National Smoke Abatement Society is to be opened in Glasgow by the Lord Provost on Wednesday next, September 30th. This is the first national air pollution conference since the great London fog of December last, which resulted in 4000 deaths. Appropriately, the Des Voeux Memorial Lecture will this year be on "Air Pollution in Relation to Preventive Medicine," by Sir John Charles, chief medical officer to the Ministry of Health. Dr. J. A. Scott, medical officer of health, London County Council, is to speak at the conference on the health aspects of the London fog, and Dr. A. Parker, Director of the Fuel Research Station, will describe how weather conditions and air pollution combined to make it so deadly. Ways and means to prevent air pollution are to be given full attention, and there will be presented for discussion a report on "Smokeless Zones," by the medical officer of health for Coventry; a paper on "The Efficient and Smokeless Combustion of Fuel Oil," by Mr. K. H. Sambrook, and two papers which examine the questions of the production, use and availability of the solid smokeless fuels. These last papers have been arranged in co-operation with the Solid Smokeless Fuels Federation. The retiring president of the Society, Alderman Professor F. E. Tylecote, M.D., of Manchester, has chosen "Smoke and the Local Authority" as the subject of his final presidential address. At the end of the business of the conference a visit is to be made, by invitation of the North of Scotland Hydro-Electric Board, to the power station and dam at Loch Sloy.

* *Archiv für das Eisenhüttenwesen*, July–August, 1953, page 353. Other recent papers by the same authors on the effects of hydrogen are in the same journal for May–June, 1953, page 211 (effect on critical straining), and July–August, 1953, page 361 (effect of electrode coatings on the formation of flakes or "fish-eyes" in welds).

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MECHANISING COLONIAL AGRICULTURE

About a year ago the Commonwealth Economic Committee produced, for the information of the governments which it represents, a report surveying trade in agricultural machinery. That report dealt solely with machinery used in the growing, harvesting and farm processing of crops, and recorded several conclusions which the committee had reached as a result of its investigations. It said, for example, that, comparing like for like, agriculture in Commonwealth countries was on the whole more highly mechanised than elsewhere, and that many of the traditional barriers to further mechanisation were being broken down. It also said that the countries of the Commonwealth were now contributing a larger proportion of the world's exports of agricultural machinery than before the war, but the comment was added that, notwithstanding the great advances in agricultural machinery, there was technically scope for much more progress. Altogether, this report was an encouraging one for the countries of the Commonwealth. It included, however, some references to the Colonial Territories, in which, with few exceptions, little use is made of agricultural machinery and modern implements, and which are dependent almost entirely upon other countries for such machinery and implements as they require.

The particular problems of those territories have been examined more recently in a paper entitled "Some Important Aspects of Mechanising Colonial Agriculture," which Mr. J. E. Mayne has contributed to the Institution of British Agricultural Engineers, and which was reproduced very nearly in full in our last issue. Mr. Mayne has concerned himself solely with the Colonial Territories which comprise about 2,000,000 square miles and contain more than 66,000,000 people. Their most valuable products include sugar, cocoa, cotton, groundnuts, rubber, vegetable oils and sisal, and, according to Mr. Mayne, among the locally-produced food crops, rice is gaining in importance in both flood and "dry" areas. Undoubtedly there is scope for the fuller development of agricultural mechanisation in those areas, provided it is kept well in mind that conditions vary from tropical swamps at sea level to wide-open wheat growing uplands at 8000ft. At the present time, of course, a great deal of attention is being paid to the African territories which comprise three-quarters of the land area of the Colonies and contain five-sixths of the people. But, from his own observations, Mr. Mayne says that Africa as a whole is the least mechanised continent, having less than 1 per cent of the world's tractors on 12 per cent of all arable land. In fact, it has been estimated roughly that throughout the Colonial Territories the tractor "population" does not add up to more than 20,000, a figure which should be set beside the 287,000 wheeled and track tractors in use in this country last year. Furthermore, agricultural tractors in the Colonial territories appear to be used principally for ploughing and for the preparation of a seed bed, and the experience which has now been gained shows that the cost of operating tractors under local conditions in many places has turned out to be much higher than was expected. At first glance, therefore, the immediate prospects of increasing the tractor population of the Colonies and of encouraging the greater use of tractor-mounted implements might not seem to be very good. Nevertheless, if the proper allowance is made for retrenchment in the groundnuts scheme, there has been a steady increase in the last three years in the quantity of tractors and implements exported from this country to the African colonies. The British agricultural machinery industry, which is always mindful of the need to expand its export business, will not pass by unheeded Mr. Mayne's comments about tractor operating costs. He says that expenditure on fuel, lubricants and wages is low compared with the cost of repairs and the replacement of parts, the high repair costs being attributable largely to the shortage of competent mechanics. The great need, in the African colonial territories at any rate, is for a reduction in the cost of repairs and of spare parts delivered to the user. At the moment, in Mr. Mayne's opinion, technical problems are not the predominant ones in the mechanisation of Colonial agriculture, as for almost every normal operation for which mechanisation is desirable "a machine can be found from either sterling or dollar sources."

We are glad to see, however, that Mr. Mayne has not hesitated to make some technical, as well as commercial suggestions in his paper. His observations on tractor width, weight and power, and toolbar clearance, and on the design of implements suitable for use in Colonial agriculture will provide some useful data for agricultural engineers who are specially concerned with the development and production of machines for export. The improvement of world food production is in a large measure dependent upon the bringing to early fruition of schemes of Colonial development which are now in hand or in the planning stage, and in all such schemes an essential factor is the contribution which agricultural engineers can make. The rapid and successful progress in mechanising agriculture in this country—and thereby raising the productivity of our farms—has been greatly assisted because engineers, in recent years especially, have been careful to study land problems and conditions. Machines and implements suited to the peculiar needs of particular areas have resulted. What has been done and is still being done in this respect in this country can undoubtedly be achieved in the Colonial territories. The factual survey which Mr. Mayne has made, pointing out as it does some of the "snags" as well as the possibilities of agricultural mechanisation in the Colonies, is a welcome addition to existing information. It will, we believe, encourage British agricultural machinery designers and manufacturers to give still more attention to those territories whose present and future machinery requirements can well be supplied from British sources.

DONCASTER'S CENTENARY

A hundred years ago the Great Northern Railway began the construction of new shops and the putting down of plant for the repair of its locomotives, carriages and wagons. Doncaster, the site chosen for this new works, was then little more than an old country town; but it lay near to the South Yorkshire coalfield, which was then being rapidly developed, and was in any case much more suitable for a railway works than Boston, where the first small workshops of the Great Northern were situated. The "Plant," for by no other name has the G.N.R. works ever been known in Doncaster, was developed on a rather cramped triangular plot, two sides of which were formed by the main line and the River Don. Not by a long way the largest of British railway works, and certainly by no means the most conveniently laid out, it grew, however, to be one of the most famous of them all, by the very distinctive types of locomotives constructed, by the quality of the workmanship put into them, and by their performance on the road. At first, Doncaster was not concerned with new

construction at all. With the locomotive department under the superintendence of Archibald Sturrock engines were purchased from various private builders. In looking through the list of new locomotives added to the stock between 1853 and 1866 there is hardly a firm famous in the early history of railways in this country that is not represented. It was, indeed, not until Sturrock had retired in 1866, and had been succeeded by Patrick Stirling, that the first new locomotive was built at Doncaster. At the present time, when such emphasis is laid on the need for general utility locomotives, it is interesting to recall that Doncaster's first engine was a mixed traffic 0–4–2, designed by Mr. Stirling for duties ranging from heavy excursion passenger trains to fast goods work. This engine was delivered on the rails towards the end of 1867.

Rarely can the chieftainship at a railway works have been held by four such outstanding personalities in succession as those who held office on the G.N.R. at Doncaster from 1853 onwards—Sturrock, Patrick Stirling, H. A. Ivatt, and Sir Nigel Gresley. Yet strangely enough they were none of them Great Northern men by training. Sturrock was for ten years an assistant to Daniel Gooch, at Swindon ; Stirling came from the Glasgow and South-Western, and Ivatt was formerly Locomotive Superintendent of the Great Southern and Western, in Ireland. Gresley was certainly a Great Northern man at the time of his appointment, having been carriage and wagon superintendent under Ivatt for several years ; but he served his pupilage under F. W. Webb, at Crewe, and went subsequently to the Lancashire and Yorkshire Railway. On the formation of the London and North-Eastern Railway in 1923, Doncaster became, for a time, no more than a divisional centre. But after the death of Sir Nigel Gresley in 1941, his successor, Mr. Edward Thompson, re-established Doncaster as the headquarters of the Chief Mechanical Engineer of the whole line ; the administrative offices were suitably adapted, and the entrance hall was decorated with the coats of arms of the constituent companies, and the names of those who held office as locomotive superintendent. To-day, Doncaster is the mechanical and electrical engineering headquarters of two regions, the Eastern and the North-Eastern ; like so many of his predecessors, the present chief, Mr. K. J. Cook, took office there as an almost complete stranger, though not the first to go straight to Doncaster from Swindon.

The express locomotives of the Great Northern Railway include some of the most distinctive and original designs that have run in this country. What was perhaps more remarkable is that Stirling, Ivatt and Gresley each produced a basic type that lasted for the whole of their respective chieftainships. Stirling's day was that of the single-wheelers —the astonishingly beautiful outside-cylindered " eight-footers " ; in Ivatt's time all the more important expresses came to be " Atlantic " hauled, just as the Gresley " Pacifics " came to dominate the scene between the two world wars. It is indeed fortunate that examples of the Stirling and Ivatt express engines have been preserved ; more than this, through the enterprise of a group of railway enthusiasts, and the ready co-operation of Doncaster and the Eastern Region motive power department, a special train, " The Plant Centenarian," has been run double-headed by the pioneer British " Atlantic " engine, Ivatt's " 990," and the first large boilered G.N.R. " Atlantic." A list of the speed records, and feats of heavy load haulage that fell to the Gresley " Pacifics " from 1935 onwards would make a long article in itself ; from the 108 m.p.h. of " Papyrus " in 1935 Doncaster progressed to the 126 m.p.h. of " Mallard " in 1938. The post-war engines designed first by Mr. Edward Thompson and then by Mr. A. H. Peppercorn, have many notable feats to their credit, though opportunities to achieve the really spectacular have been almost non-existent, so far. One of the " A2 " engines of Mr. Peppercorn's design was the 2000th locomotive built at Doncaster. But despite the achievement of " Mallard " the most famous Doncaster express engine of to-day is still, perhaps, Gresley's first streamliner, the " Silver Link." After the speed trials with " Papyrus " in the spring of 1935, the " Silver Jubilee " train was designed and built within the very short space of five months, and " Silver Link," with a total absence of teething troubles went straight into the fastest express service ever scheduled in this country, and ran the double trip between King's Cross and Newcastle every day for a fortnight, with absolute punctuality before the second streamlined engine was ready to take a share. Those, indeed, were some of Doncaster's finest days, and it was fitting that the " Plant Centenarian " express hauled on its outward journey by the two Ivatt " Atlantics," should have been hauled on the return by so celebrated a Doncaster engine as the " Silver Link."

Administration of British Transport

FOLLOWING upon the statement made by the Minister of Transport in the House of Commons on July 28th in respect of the disappearance of the various Executives (with the exception of London Transport), the British Transport Commission has made the following announcement about the arrangements which will operate on and from October 1st. The arrangements to be made for carrying on the management of British Railways represent, it is emphasised, an interim organisation pending the reorganisation of British Railways envisaged under the Transport Act of 1953. The Act gives the Commission twelve months, or longer if the Minister of Transport agrees, to complete its scheme of railway reorganisation for submission to the Minister and Parliament. The arrangements will ensure continuity of administration and will be without prejudice to the Statutory scheme. The Commission's primary function will be to control major policy (including finance) and general direction, and for this purpose and to ensure a common line of action in matters of nation-wide significance as well as for the quick settlement of inter-regional questions, and for the conduct of certain common and central services, the Commission will be assisted by an expert headquarters staff. The Regions of British Railways will remain for the time being as now constituted, but the chief regional officers will be given certain additional powers and will be known as chief regional managers. Each chief regional manager will be responsible for all railway activities (commercial, operating and technical) in his region, and will report directly to the Commission. It will be the duty of the chief regional managers to co-operate with the other sections of the Commission's undertaking (viz., London Transport, the omnibus companies, the docks and inland waterways, British road services, and the hotels and catering services), so as to develop and improve all the transport resources of the Commission's undertaking as a whole. The chief regional managers will be : London Midland Region, J. W. Watkins ; Western Region, K. W. C. Grand ; Eastern Region, C. K. Bird ; Southern Region, C. P. Hopkins ; North-Eastern Region, H. A. Short ; Scottish Region, T. F. Cameron.

As from October 1st, the Commission will become the employers of all officers and staff of British Railways.

As already announced, three other Executives —the Road Haulage, Docks and Inland Waterways, and Hotels Executives—will be discontinued as from October 1st next, and the following organisations will take their place. The Docks and Inland Waterways Executive will be replaced by a Board of Management. The new board will consist of Sir Reginald Hill, the present chairman of the Executive (chairman), Sir Robert Letch, and Mr. J. Donovan. The Hotels Executive will be replaced by a Hotels and Catering Services Committee of the Commission, of which the chairman will be Sir Harry Methven, who has been appointed a part-time member of the Commission. This part of the Commission's undertaking will be known as British Transport Hotels and Catering Services. Mr. F. G. Hole, a member of the Hotels Executive, has been appointed Chief of the Hotels and Catering Services. London Transport will continue unaltered as an Executive of the Commission, under the chairmanship of Mr. John Elliot, for a period of at least one year, as announced by the Minister. The new organisation for British Road Services, under a Board of Management, was announced by the Commission on August 20th last. The Commission's road passenger undertakings in Scotland and the Provinces will continue to be managed as at present. At the end of this month the offices of the Commission will be moved to 222, Marylebone Road, the present offices of the Railway Executive.

The Aerodynamics Division of the N.P.L.

THE Department of Scientific and Industrial Research has announced the appointment of Dr. W. P. Jones as superintendent of the aerodynamics division of the National Physical Laboratory. He succeeds Mr. Arthur Fage, F.R.S., who has recently retired. Dr. Jones was educated at Lampeter and Oxford and graduated with first class honours in mathematics. After reading physics for two years, he joined the staff of the N.P.L. in 1935. He is an acknowledged authority on aircraft oscillations and in recent years has had charge of the work of the aerodynamics division concerned with problems of flutter and stability. Mr. Arthur Fage has spent forty-one years in the service of the aerodynamics division of the N.P.L., which he joined after studying at the Royal College of Science. At that time, 1912, the division existed as a section of the engineering department, but its work expanded rapidly when the first world war demonstrated the importance of aeronautical research. During that war Mr. Fage concentrated on such problems as the pressures over airships, the tearing of balloon fabrics and the characteristics of aerofoils. In 1920 Mr. Fage began his extensive researches into boundary layers and turbulent flow, many of his findings being published by the Royal Society, of which he was elected a Fellow in 1943. Since his appointment as superintendent of the aerodynamics division in 1946, Mr. Fage has been concerned mainly with the improvement of the wind tunnel equipment and the planning of the new high-speed laboratory at Teddington. Mr. Fage is a Fellow of the Royal Aeronautical Society and of the American Institute of Aeronautical Research. He was awarded the C.B.E. in the Coronation Honours in recognition of his services to aeronautics.

POST-GRADUATE LECTURES AT BATTERSEA POLYTECHNIC.—The special lecture courses for post-graduate engineers to be given at Battersea Polytechnic this winter include a course on each of the following subjects : prestressed concrete design and construction ; the theory and design of shell roofs ; elements of law relating to civil and mechanical engineering ; and the organisation of civil engineering contracts. Details may be obtained from the Secretary, Civil Engineering Department, Battersea Polytechnic, London, S.W.11.

Institution of Naval Architects

No. I

THIS year the Institution of Naval Architects was invited, by the Koninklijk Instituut van Ingenieurs, to hold its autumn meeting in Holland, and on Monday afternoon, September 14th, the delegates were officially welcomed at the Kurhaus, Scheveningen by the chairman of the Instituut, Mr. L. Neher. The Instituut, he remarked, greatly appreciated the acceptance of its invitation by the Institution of Naval Architects, and recalled that the Institution last visited Holland in 1923. He apologised for the unavoidable absence of Dr.-Ir. J. A. Ringers, C.B.E., who unexpectedly had to sail for South America, and included in his remarks a review of the knowledge required to be assimilated by naval architects, and also some observations upon their work, training and responsibilities. The need for the continuance of untiring research was emphasised, to produce the many classes of ships having varying characteristics suitable for trading, on an economic basis, in many parts of the world.

Viscount Runciman, in reply, thanked the Instituut for all the preparations made for the comfort and entertainment of the Institution of Naval Architects, and commented upon the greater publicity accorded to the advances made in the aircraft industry compared with those made in shipbuilding. This, he thought, was because changes in aircraft design were more spectacular while ships underwent small but continuous improvement.

Immediately upon the conclusion of the opening speeches a one-minute silence was observed in honour of the memory of Vice-Admiral F. Stam, D.S.O., Chief of the Navy Material and Controller of the Royal Netherlands Navy, who had died suddenly only a few days before the meeting was to open. He had undertaken to give a lecture on "The Economic Aspect of the Building of Small Ships," and this was delivered by Captain K. van Dongen, of the Netherlands Navy. The lecture, in particular, dealt with the coastal minesweeper building programme, under which Holland was to construct a total of thirty-two of these craft. To carry out such a contract required careful planning, and the paper described the steps taken by the Dutch shipbuilders and the Navy to standardise design, to organise a flow of materials, such as aluminium alloys and timber, and to arrange for the production of the necessary main propulsion and auxiliary machinery. The lecture was illustrated by maps which indicated the position of the building yards and also where the various component parts were being manufactured.

The meeting was continued on the morning of Tuesday, September 15th, with the reading of the following paper :—

PRESENT-DAY DEVELOPMENT OF SHIP MODEL RESEARCH IN THE NETHERLANDS SHIP MODEL BASIN AT WAGENINGEN

By Professor Dr.-Ir. W. P. A. van Lammeren

Synopsis

The development of model research in the Netherlands, in the N.S.M.B. at Wageningen and in the Laboratory for Naval Architecture at Delft, progresses nowadays along carefully thought-out lines. The work concerns a large number of subjects, which will be classified and discussed in this paper in their logical order. The aim of all the experiments is the constant improvement of recommendations supplied to shipowners and shipbuilders who avail themselves of the services offered by the model basin.

The subject-matter is classified under two main headings :—

First, research aiming at improvement in hull forms, propellers and rudders.

Hull forms :—Incidental research during work on orders ; research on systematically varied ship models ; and more fundamental research.

Propellers :—Systematic propeller series ; development of the propeller theory ; improvement in methods of design (correction factors) ; cavitation and the problem of cavitation erosion ; and special constructions.

Combination of hull form and propeller :—Incidental research during work on orders ; and the influence of flow irregularity on cavitation characteristics and efficiency.

Secondly, research dealing with the correlation between tank results and trial trip and service results ; The influence of scale effect ("Victory," "Arabia," and "Marnix" projects) ; the influence of roughness of the hull form ("D. C. Endert Jr.," project) ; the influence of flowing and restricted water ("Arabia" project) ; the influence of wind and seaway ("Victory" project).

Discussion

Dr. R. W. L. Gawn : This paper gives assurance that past achievements of ship model research in the Netherlands will be more than maintained in the future.

Fig. 1 in the paper is a good statistical presentation of the results of the model tests of the particular ship concerned, but it is not very useful for comparison with other ships of different sizes, and I would like to call attention to the old elements of form diagram, proposed by R. E. Froude, which gives much more information over a range of displacement and loading, and has always proved to be extremely useful.

It is noted that the author proposes to carry out open water tests on larger propeller models than formerly, namely, on 42cm diameter models (about 16½in) in lieu of 24cm for the earlier Wageningen series. This change is to be commended, because it was made clear in my paper on propellers, presented to the Institution last year and dealing with models of 20in diameter, that there is a possibility of considerable scale effect on the smaller series.

I am interested in the author's comments on propeller theory and his reference to the mathematical maze presented by the calculation of some of the correction factors involved. Nevertheless, the theory appears to be useful in a comparative sense, although it has its limitations in an absolute sense.

On the question of the avoidance of cavitation with hollow face blade sections, I think that, although with certain classes of propeller improvement can be achieved with the conveniently named "constant velocity" sections, it cannot be assumed that that will apply for every type of propeller.

The device for inducing a controlled velocity field in the cavitation tunnel is interesting, and I hope the author will give some particulars of it. The use of wire meshes appears to be deprecated, however. We use wire grids, which have rod components, and by a logical grading of sizes we get very useful results.

With regard to the programme of trials on the "D. C. Endert Jr." is the distance astern of the ship model when being towed for resistance tests sufficient to avoid any effect of propeller action on the towed model ? We have found from tests on models, when using tugs that even with a distance apart of several ships' lengths the propeller race still has a significant influence. In the self-propelled test, was the propeller pitch adjusted to compensate for the greater resistance due to the scale of the model or was it allowed to run at greater revolutions ?

Dr. G. Hughes : While the paper does not lend itself to a great deal of technical discussion, it gives a survey of the work being done by way of research and development on ship form and an opportunity for those concerned with tank work to see how their own programmes link with those of others. At the National Physical Laboratory we have been pursuing ship model correlation work at the model end, and on the friction side of the work we have carried out a programme with planks and models. Professor van Lammeren refers to work with plates at very low Reynolds numbers and at Teddington we have reached a Reynolds number about half the low value given in the paper.

The author refers to the necessity of determining the resistance of turbulence stimulators, and I would like to know the type of stimulators used and how the resistance was determined, because I find it impossible to measure the resistance of the stimulator itself. We hope to publish next spring the means adopted of determining the drag of the stimulator. It is clear from work done in recent years that form drag, in addition to the purely frictional part of the resistance of the model, is subject to scale effect. It has been the custom to estimate the ship results by correcting for the estimated skin friction of the model according to laws deduced from plane surface work ; but we need to introduce a correction for form drag.

Professor A. F. Lindblad : I suppose that the models in Fig. 1 are compared with the standard Taylor series. That is not a good comparison, because for low-speed ships we have been able now to arrive at much better forms, although when these comparisons were started it was a good comparison.

In the section of the paper headed "Improvements in Designing Methods (Correction Factor)" it is stated that only those with experience in this field will be able to handle the theory in such a way that good results will be obtained. Later the author states that some of these factors were submitted to the Mathematical Centre for perusal. That is discouraging, because those factors help the naval architect, who in his practical work has many problems to handle and has not time to go into these theoretical mathematics.

The author states that it is of importance to analyse the greatest possible number of trial trip and service results of ships, and that this is being done under the guidance of Professor Bonebakker, of the Technical University at Delft. In that lies hope of achieving correlation between models and ships, and the work now in progress will help all naval architects in that direction.

Mr. K. G. Evans : It is interesting that Dr. van Lammeren is tackling the problem of relating the results of open water tests on propellers with those obtained in the cavitation tunnel. To obtain the wall correction the direct method is proposed, but if the experimental rig is on the scale shown in Fig. 2 the velocity field of the boat would probably cause a significant non-uniform flow at the propeller.

It is of interest to recall that an investigation was carried out on the wake forward of the shroud supporting the dynamometer for the open water propeller experiments described in Dr. Gawn's 1953 I.N.A. paper. Theoretically, the shroud was assumed to be represented by an elliptic cylinder (upper half) ending in an ellipsoid at the lower end. The calculation suggested that the wake induced by the shroud in the plane of the propeller would vary from 0·69 to 0·83 on the vertical through the propeller axis and somewhat less for the whole disc area, between ½ per cent and ¾ per cent. This was

confirmed by pitot tests. Comparing Fig. 2 of Dr. Gawn's paper with Fig. 2 of the present paper, the dimensions of the boat are relatively much larger than the shroud, so that the induced wake might be expected to be a few per cent of the same order as the wall correction to be measured.

Many would be ready to agree that hollow face sections with rounded leading edge offer the widest latitude against cavitation in a variable wake, but the gains in propulsive efficiency by using such sections are only slight except at very high speeds. The benefit stems from reduced cavitation, thereby causing less erosion damage and vibration. In the report, "Summary of Aerofoil Data," published in 1945 by the U.S. National Advisory Council on Aeronautics, the N.A.C.A. mean line $a=1$ gives the velocity increment due to the design load distribution of $\frac{1}{2} C_L$, compared with the maximum additional velocity of $\frac{1}{\pi} C_L$ given by the circular arc camber. The velocity is practically constant over the chord for the N.A.C.A. mean line, whereas it is approximately elliptical for the circular arc. For maximum latitude against cavitation at the leading edge for varying angles of attack, an elliptic-shaped nose has much to recommend it and, to avoid induced vibration from eddy shedding at the trailing edge, it is desirable to finish the tail of the section more sharply.

I endorse the author's doubts on the accuracy of the published figures for camber correction; at Haslar they have proved to be generally too low. A very large area propeller of B.A.R. 1.1, which was designed from theory several years ago, was 8 per cent low in pitch. Since then many designs have followed, and we have evolved a procedure for design which uses the pitch correction technique given in Dr. Lerbs' 1952 S.N.A.M.E. paper, and also incorporate an arbitrary increase in camber correction based on experience derived from propulsion tests on 12in diameter models in the cavitation tunnel.

Dr. H. W. Lerbs: I will restrict myself to some remarks on the fundamentals of propeller theory, and the reasons why I consider the induction factors as the functions of primary importance in propeller theory, and to mentioning two applications of the theory, viz., to the "wake-adapted" propeller and to the contra-rotating propeller. Work at the Taylor Model Basin is aimed at establishing the minimum condition on a basis of the induction factors, and the application of these factors instead of the Goldstein function is necessary, since the free vortex sheets differ from the true helical shape. Although the analysis yields an integral equation for the optimum circulation distribution, the assumption of axis-symmetrical inflow is implied and it must be shown that the peripheral non-uniformity of the wake is of minor influence on the optimum circulation distribution. This leads to a problem of unsteady flow with which additional losses of kinetic energy are associated. The neglect of the peripheral non-uniformity is justifiable when the non-steady flow losses are small as compared with the power input. For an arbitrarily given wake field the result is obtained that the losses associated with non-steady flow are proportional to the number of blades, to the chord length and to the square of the amplitudes of the harmonics of the wake, and this loss amounts to about 1 per cent of the power input.

I was interested in the reference to contra-rotating propellers and analytical work relative to this problem is being done at the Taylor Model Basin on the basis of induction factors. To establish the mutual interference of the propellers the induced velocities must be known at and between the blades, and this necessitates an extensive evaluation of Biot-Savart integrals, which is being done by means of the electronic calculator.

Professor E. V. Telfer: Comparing the texts and subjects of the papers presented at this meeting with those presented at a meeting here thirty years ago, one outstanding difference is the present-day accent on research.

It is difficult to discuss the paper in detail, but there is one point that I would make; I do not like over-emphasis on the Karman-Trefftz section or even the Walchner section, because none of these investigators had first-hand contact with the actual design of propellers. Full credit should be given to the first Sir John Thorneycroft for the design of what we now call the hollow-faced section, which was the increasing axial pitch section and was the equivalent of the Karman-Trefftz section and was also the successful propeller in the original "Daring" experiments. It would be interesting if we could have a detailed plan of that earlier propeller in order to see how much was known thirty years ago about the most efficient way in which to overcome the cavitation problem.

Dr. G. C. Manning: I plead for the use of non-dimensional coefficients in reporting the results of research, for I think the advantages accruing from their use extend beyond the fact that they have the same value in metric units as well as in English units; fundamentally they give us a better understanding of the value of the results quoted.

Dr. F. H. Todd: In 1951, in Washington, Dr. Livingston-Smith, of the British Shipbuilding Research Association, gave a detailed account of the research programme which was in hand in Great Britain. To-day we have heard the programme carried out at the Wageningen tank, and tomorrow I hope to present an outline of the programme which the United States Navy is carrying out in the field of hydro-mechanics. I want to bring those three together because they show how much is being done to-day in hydro-mechanics research, a field which has been considerably neglected in comparison with that of aeronautics.

Other speakers have made the point that the model might be influenced by the wake of the towing ship. We have measured the thrust of the propellers on a number of U.S. Navy ships, and from that we get the resistance of the ships by making one assumption, that the thrust deduction factor which we measure on the model also applies to the ship. At no time have we ever measured a full-scale thrust deduction factor. That necessitates measuring the full-scale thrust and the full-scale resistance; and if we can measure those two on a number of ships and gain some confidence from the fact that we can apply the model thrust deduction to the ship we shall have confidence to use a greater number of trials to obtain the roughness coefficient. Once when we painted a cruiser with new paint we increased the power consumption by 23 per cent, so that we are not dealing with small quantities.

Mr. V. G. Shepheard: Arising out of the point raised by Professor Telfer, I am not sure whether the information is available with regard to the early "Daring" propellers, but I will have the matter investigated and if the particulars are available I will include them in the discussion.

It is a coincidence that recently we have been carrying out a series of tests, on the new "Daring" class, of different types of propellers and we have also made tests on another destroyer with propellers of varying blade shape and blade areas, and hope to gain information under full-speed ship conditions and also at cruising speed.

Professor L. C. Burrill: Some of us have had the privilege of boarding the "D. C. Endert, Jr.," and we are overwhelmed by the technique which has been followed and which will give us full data concerning a ship 70ft long. Perhaps I may mention the fact that tests were made on a 76ft model of the "Mauretania" as early as 1906. They were carried out, I believe, in the Albert Edward Dock near Newcastle, but unfortunately the results were buried in the archives of the builders, Swan, Hunter and Wigham Richardson, Ltd. To-day an entirely different state of affairs exists, for the results of work of this kind are published immediately.

In Fig. 1 Professor van Lammeren has published a C_E curve which gives a non-dimensional coefficient in terms of shaft horsepower, and it might be better if workers in Holland would use the term draught horsepower which Taylor introduced, meaning the definite power delivered to the screw.

About the so-called Karman-Trefftz sections, I have been aware of the design and fitting of propellers having hollow-faced sections for some years, but it was not until I visited the Wageningen tank three or four years ago that I discovered there were such things as Karman-Trefftz sections. There is no difference, I think, between sections having circular arc definition of back and face, and a Karman-Trefftz section. I feel, therefore, we are misled when a name such as Karman-Trefftz is given to them. Experience with the Karman-Trefftz hollow-faced section has not been exactly unmixed, for I have known propellers altered from flat-faced to hollow-faced sections and cavitation erosion has appeared on the face side.

After the reading of the first paper the meeting was honoured by the presence of His Royal Highness the Prince of the Netherlands, Inspector-General of the Royal Netherlands Navy, and there followed the ceremony of presenting His Royal Highness with the scroll of honorary membership of the Institution of Naval Architects. In making the presentation Lord Runciman thanked the Prince of the Netherlands for honouring the Institution by consenting to accept honorary membership and went on to mention his technical achievements in the air, and Lord Runciman felt that as there was a close connection between the air and the sea, His Royal Highness would not be a stranger to technical matters concerning the sea.

(To be continued)

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1

UNIFIED MACHINE SCREWS AND MACHINE SCREW NUTS

No. 1981 : 1953. Price 6s. The publication of this standard marks a further step in the unification of screw threads. It is complementary to the standards for hexagon bolts and nuts which were issued two years ago and provides, as they did, for screws having unified threads and heads selected from a range already standardised in the United States.

Whilst it is generally understood that unification of screw threads has been limited to sizes ¼in and upwards, provision is also made in this standard for a restricted selection of American number sizes, viz., 4–40, 6–32, 8–32, 10–24 and 10–32, which are to be regarded as unified for purposes of attachment screws only. The standard covers slotted and recessed head screws of the following types :—80 deg. countersunk and raised countersunk, pan, cheese and hexagon heads; dimensions of nuts and washers are also specified. Details are given in appendices of the flushness gauge for checking countersunk heads.

A Dual-Purpose Prestressed Concrete Bridge

CALVERTON Colliery is about 7 miles north of Nottingham; it was the first large colliery to be completed by the National Coal Board, and was opened about a year ago, at which time a short description of it was published in this journal (THE ENGINEER, October 3, 1952). We have now received from the Cement and Concrete Association some details of a 74ft span bridge which was built as part of the colliery construction programme.

The layout of the colliery is such that the winding shafts are separated from the coal preparation plant by an existing roadway and it was therefore necessary that there should be a railway bridge to connect the two. It was also necessary to transport coal and refuse between the pithead and the coal preparation plant. The planning authority would not permit a separate overhead conveyor structure, and it was therefore decided to try to utilise the space between the deck and soffit of the bridge to accommodate the conveyors. A minimum headroom of 5ft was required for this purpose between the underside of the upper (railway) deck and the lower floor which would carry the conveyors. The design therefore envisaged a minimum thickness of railway deck and conveyor floor, as the rail level was limited by permissible gradients, and the soffit level by the 16ft 6in headroom necessary for the road. Furthermore, interruption to traffic using the road beneath the bridge had to be minimised during construction. A design in prestressed concrete, much of it precast, was therefore chosen.

The bridge as finally designed has two precast, prestressed girders placed parallel at 16ft 8in centres, as shown in the cross-sectional drawing on this page. Spanning between the girders there is an upper deck to carry the railway and a lower floor to carry the conveyors. The underside of the lower floor forms the soffit of the bridge. Prestressing was carried out on the Freyssinet system throughout. The abutments are of mass concrete faced with mottled Alton stone and are sited on the colliery shaft pillar so that the customary provision for the jacking of bridge foundations in mining areas was not required. Our second illustration shows the completed structure.

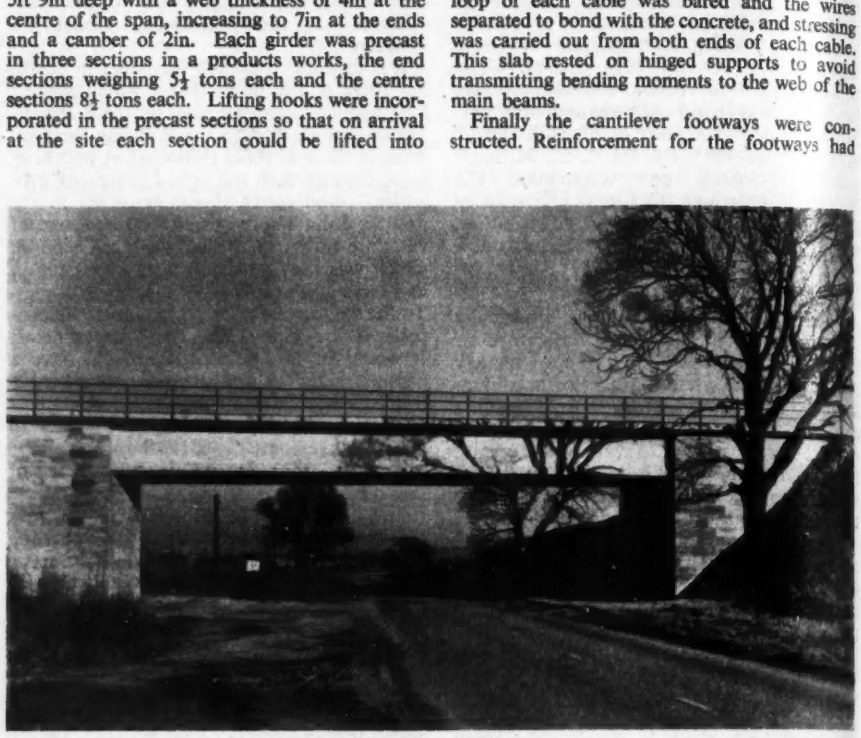
The maximum permissible live load on the bridge is 104 tons—due to two diesel locomotives and a loaded truck weighing 42 tons and 20 tons respectively. The speed of any train is restricted to 10 m.p.h. The weight of the coal and refuse conveyors are 135 lb per foot run and 115 lb per foot run respectively, and the maximum loads on the coal and refuse conveyors at any one time for the span of the bridge are 4·46 tons and 3·8 tons respectively. For the purpose of computing the maximum stresses in any member the requirements of B.S. 153 (girder bridges) were observed in the provision for impact and other forces. Deflection and expansion is taken up by Freyssinet hinges at the girder bearings.

The two main girders are 77ft long overall and 5ft 9in deep with a web thickness of 4in at the centre of the span, increasing to 7in at the ends and a camber of 2in. Each girder was precast in three sections in a products works, the end sections weighing 5½ tons each and the centre sections 8½ tons each. Lifting hooks were incorporated in the precast sections so that on arrival at the site each section could be lifted into position on bearings and temporary timber towers. Once the complete girders had been lifted into position six cables of twelve 0·2in diameter wires were threaded through ducts which had been formed in the units during casting. The ¾in joints between the sections of the girders were filled with a dry mortar of cement and sand in equal proportions. Stressing was carried out from both ends of each girder and after stressing the cables and ducts were grouted under pressure.

The conveyor floor was then constructed. It is formed mainly of hollow precast units spanning between the girders with precast concrete channel units at 4ft 6in centres to accommodate the transverse cables which had plastic sheathing. The hollow channels were then filled with *in situ* concrete. Longitudinal sheathed cables were located in the 2in concrete screed on top of the precast units and anchored in *in situ* strips between the girders over the bearings. The transverse cables were stressed first, thus forming the main beams and the lower (conveyor) floor into a monolithic whole. The longitudinal cables were then stressed to provide sufficient prestress in the beams and lower floor to carry the upper (railway) deck and the live load.

The top deck was cast *in situ*. The transverse cables, sheathed in plastic, were placed before concreting began and were looped so that both ends of each cable were anchored on the same side of the bridge, but cables were anchored alternately on opposite sides of the bridge. The loop of each cable was bared and the wires separated to bond with the concrete, and stressing was carried out from both ends of each cable. This slab rested on hinged supports to avoid transmitting bending moments to the web of the main beams.

Finally the cantilever footways were constructed. Reinforcement for the footways had been left protruding from the top flange of the main beams.



Bridge at Calverton Colliery

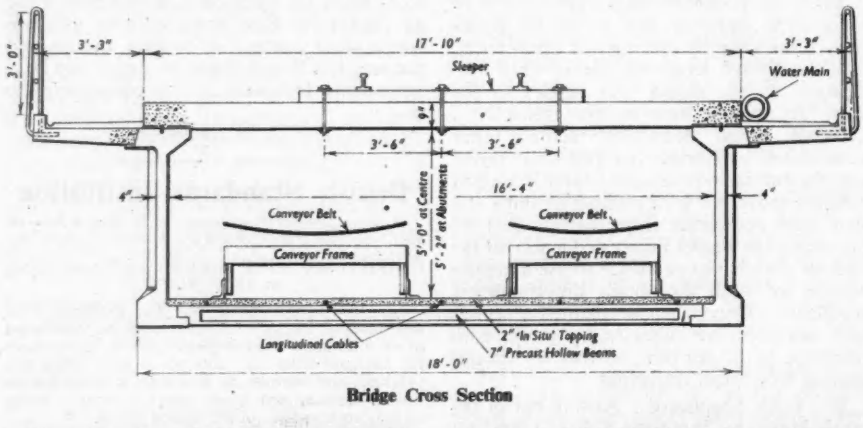
On the approaches to the bridge the conveyors run below ground and the conveyor housing roof is a 9in prestressed slab which carries the railway running above.

The concrete mixes used in the construction of the bridge were a 1 : 1½ : 3 mix for prestressed work, a 1 : 2½ : 3¾ mix for reinforced concrete work, and a 1 : 3 (fine aggregate) topping on the conveyor deck and bridge.

All batching was by weight and the concrete was vibrated. A minimum crushing strength of 4000 lb per square inch was required in the concrete at the time of stressing and a minimum of 6000 lb per square inch before the bridge was used. The maximum design compression, due to the train load, is 1472 lb per square inch. The design does not permit tension to develop in the concrete under any condition of loading.

A specimen section of railway deck was cast and tested to destruction at the products works, under the supervision of the Building Research Station. The deck specimen, which was 5ft 4in wide and 9in deep, was supported on a clear span of 16ft 3in.

The bridge was built for the East Midlands Division of the National Coal Board; the engineer was Mr. H. C. Griffiths, in collaboration with the Prestressed Concrete Company, Ltd. The contractor was Fletcher and Co. (Contractors), Ltd., of Mansfield. The precast bridge girders and the precast flooring units were cast at the Manchester works of Matthews and Mumby, Ltd., who also supplied and fixed the prestressing cables and carried out all post-tensioning on site.



Bridge Cross Section

VENICE REFINERY PLANT.—A catalytic polymerisation plant producing high-grade motor spirit from gas feed stock has been commissioned at Porto Marghera refinery, near Venice and a catalytic cracking unit is to be installed at the refinery to produce high-grade motor spirit and gas feed stock.

Terminal Buildings at London Airport

PROPOSALS for the development of the central terminal area at London Airport were made known on Wednesday of last week at a Press conference held by the Minister of Civil Aviation, Mr. Lennox-Boyd. There has been a great deal of interesting constructional work in progress at London Airport for the past few years, as we have noted in these columns from time to time. It may be recalled that there is a diamond-shaped area of ground in the centre of the runway system, which has an area of 158 acres, and has been set aside for the permanent terminal buildings which will eventually replace the temporary buildings now in use at the Bath Road entrance of the airport. A tunnel has been built under the northern runway to give access to the central area for vehicles and pedestrians. Three buildings are at present to be constructed in the terminal area, namely, the control tower, a passenger handling building, and a building for the use of air crews and of the public. The control tower and building is to be almost in the centre of the diamond, with the passenger handling building on the south-east side, and the third building on the eastern corner. The accompanying illustration shows a model of the three buildings, from which a good idea of their layout and appearance may be obtained. The remaining three sides of the central diamond are being left free for future development, and there is space for a second building next to the control building, should it be needed in the future. Preliminary work on the construction of these buildings was started in 1951, and they are due to be partly in operation in 1954 and completed in 1956. The completed group will give very comprehensive facilities for passengers, air crews, airport staff and visitors, and for the control of aircraft; the tower of the control building is planned as the focal point of a highly complex system of radio and line communication, radio and radar navigational aids, airfield lighting, and ground movement control. It is expected that these technical facilities, when installed, will be the most advanced and comprehensive in the world.

All movements of aircraft approaching and departing from the airport and all movements of aircraft and motor vehicles on the airport movement area will be controlled from the control building. This building will also contain the headquarters of airport management, aeronautical telecommunications, the medical centre, restaurants and welfare facilities for all staff employed in the central area. The building is arranged in a T-shaped plan with a control tower, 122ft 6in high, at its fulcrum.

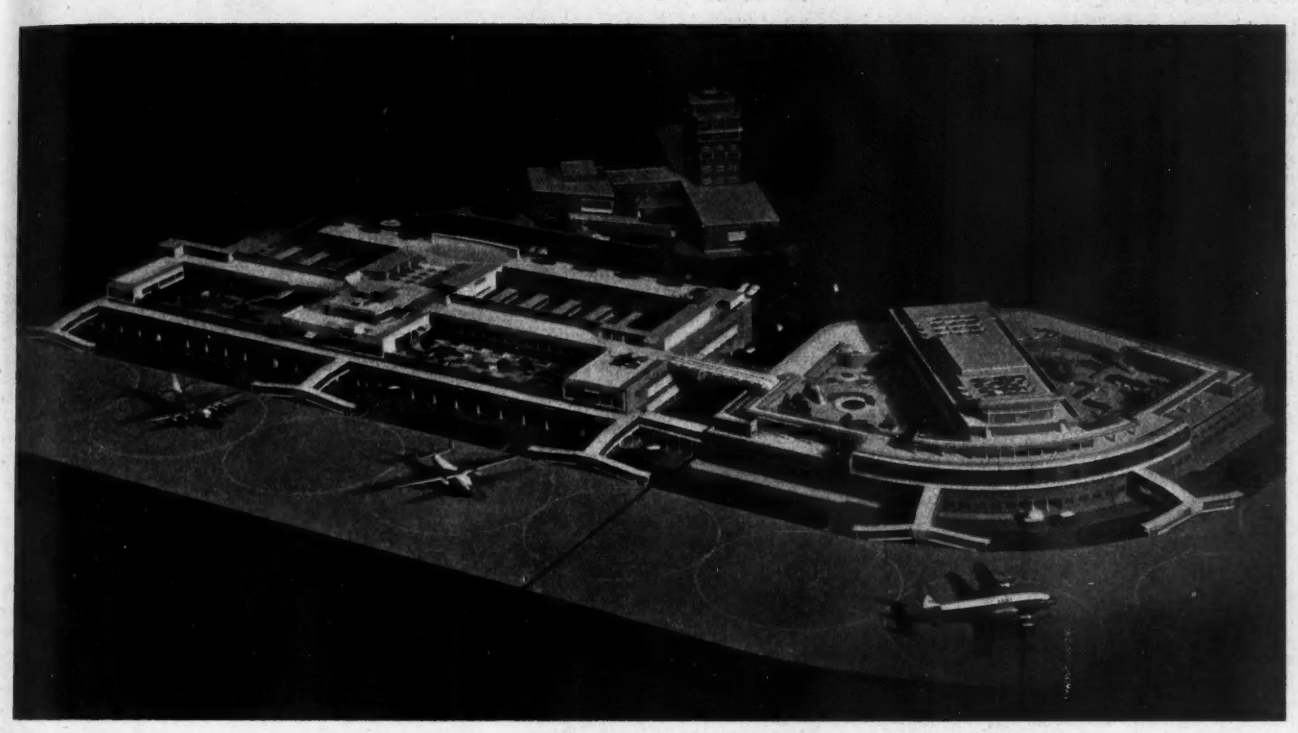
The air traffic control services will occupy the upper floors of the control tower and a glazed penthouse on the roof. The shape of the tower was determined by a number of practical considerations, such as the need to provide the view required by air traffic control and the layout of technical equipment from a central vertical duct. The arrangement of the tower walls on varying planes at angles to each other is intended to minimise the interference which large flat surfaces are likely to cause to radio approach and landing aids. The tower, in plan, consists of two intersecting trapeziums with staircases between them and the central services duct. The wider trapezium faces east and contains the approach and ground movement control rooms with windows on three sides; the narrower trapezium faces west and contains smaller rooms serving the control organisation.

The central services "core" extends to the full height of the tower and contains the lifts, ventilation trunking and the pneumatic tube and cable duct. Underneath all control rooms there will be a false floor, in which cables and tubes can be run from the vertical duct to any position in the room, thus ensuring flexibility in the layout and ease of maintenance of the equipment.

The penthouse on the roof will be the aerodrome control room and from it an all-round view of the airport is obtained. Below it will be the approach control room, which is to be 15ft high to accommodate a control information panel ("tote" display), which will be placed against the back wall in the widest part of the room and with direct access to the vertical duct. The control room will be cantilevered out beyond the face of the tower and enclosed with glazing sloped to avoid reflection on the three remaining sides. All aircraft and motor vehicles on the movement area will ultimately be controlled from the ground movement control room, which will be immediately below the approach control room and be of the same shape. This room is designed to take a mimic diagram of the aerodrome on the wall next to the vertical duct. The windows on three sides will also be sloped to avoid reflection.

The passenger handling building has been carefully planned with the idea of causing the minimum inconvenience to passengers in carrying out the inevitable formalities of Customs, &c., as smoothly and quickly as possible. The whole of the ground floor of the building is given over to the handling of baggage, the accommodation of technical staff and equipment, and the preparation of food and other services. The first floor is given over to passengers. On the second floor there will be office accommodation for operating companies, an extension of the main concourse and a restaurant as well as roof gardens for the general public. The upper floors are planned as a series of terraces for spectators.

The "internal" section of the building forms an appendage to the "Continental" section and has its own separate entrance. It bypasses the Customs barrier but is linked to the main entrance concourse in the Continental section at first floor level. The main function of handling passengers is concentrated on the first floor. At this level departing passengers or those arriving from abroad pass through one or other of ten parallel channels. Each channel is self-contained, the route being unmistakable and free from interruption by cross-flow. The channels are on two levels and a passenger arriving by coach from the town terminal passes through the appropriate channel entrance at ground floor level and reaches the main concourse at first floor level by escalator, his luggage following a similar route by conveyor belt. The channels with the conveyor belts are arranged in pairs so that two can be used together whenever it is necessary to handle unusually large aircraft loads. Each channel is completely reversible and thus capable of handling either inward or outward bound passengers. Inward and outward traffic peaks seldom coincide, and by making the channels reversible fewer of them are needed. The building



Model of Proposed Central Terminal Buildings at London Airport

is intended principally for "short-haul" passengers, and it will have a peak capacity of about 1200 passengers per hour.

The handling of aircraft operations and crews and the provision of amenities for the public are to be provided at the eastern apex building. It will provide for aircraft and crew clearances, including Customs examination, aircraft load control, meteorological planning and flight planning and crew briefing. The amenities provided for the public, which are completely isolated from the operational functions of the building, are very comprehensive, with access to the roof gardens, an exhibition hall, post office, news cinema, and so on. The long curved window area shown in the illustration is for a restaurant.

All three buildings are designed on a grid of 12ft with a steel-framed main structure, with external walls of brick, stone or glass. The floors and roofs are, for the most part, precast units and the remainder are normal reinforced concrete construction. The Customs hall in the south-east face building has a roof construction of exposed welded portal frames. False ceilings are provided throughout most of the buildings to house ventilating ducts, service pipes, cables, pneumatic tubes, &c. The buildings are sealed as far as possible from external noise and the control rooms and offices have double glazed windows. Acoustic treatments and finishes are used in the control room and telecommunications rooms, and absorbent materials in other parts to reduce internal noise. Artificial ventilation is provided for all the public rooms and all internal parts of the building. Heating is either by ceiling or floor panels, with radiators in offices served through heat exchangers from the central high-pressure hot water system. A high standard of artificial illumination has been designed for all parts, according to their use.

The three buildings are being constructed under the supervision of the Director-General of Works of the Air Ministry. The architect is Mr. Frederick Gibberd and the consulting engineers are Sir William Halcrow and Partners, G. H. Buckle and Partners, and Ewbank and Partners. The main contractor is Taylor Woodrow Construction, Ltd., and Redpath, Brown and Co., Ltd., is the contractor for the steelwork.

We understand that the cost of London Airport, as planned up to the present, will total about £26,000,000. The total cost of the development of the central area, including the access tunnel, was stated to be about £6,750,000, the three buildings alone costing about £3,500,000. The traffic handled at London Airport is steadily increasing, and in 1955, the first summer with the terminal buildings in operation, it will be further increased, for Northolt Airport will be closed, as part of the Ministry of Civil Aviation's plan to reduce its operational airports serving London from seven to three.

Institution of Naval Architects in Holland

LAST week the Institution of Naval Architects held its Autumn Meeting in Holland and besides the presentation of a number of technical papers the members and their ladies were able to see something of the country itself, to see the progress made in reconstruction and development, and to see a good deal of the shipbuilding and kindred industries. They were also entertained at a number of functions by their Dutch hosts.

On Monday morning, September 14th, before the formal opening of the meeting, Professor Ir. H. E. Jaeger gave an informal but informative talk upon the Netherlands, during the course of which he outlined the difficulties facing the Dutch people, in particular the problem of the increasing density of population and the constant struggle to win land from the sea. He outlined the general process of forming the land and gave details of the scheme to reclaim the Zuyder Zee, a plan which was first thought of in 1667, but was not adopted until 1918. As a result, a dyke some 30km in length now encloses 3500 square kilometres of the Zuyder Zee, of which 2250 square kilometres will become polderland, the remainder forming a lake for regulating the efflux of river water. Professor Jaeger talked about the present state of the development of the polders and went on to mention the flood disaster of January and lessons learned from that catastrophe. He next talked about the capital, Amsterdam, its shipbuilding and its museums, and made mention of Haarlem, Leiden and Alsmeer, the flower centre. He had something to say about Dordrecht, the oldest city of Holland, and also about Rotterdam, and concluded his talk with a brief description of The Hague and items of interest to be found in that city. In the evening there was a reception held at the Hotel Kasteel Oud-Wassenaer by the Minister of Economic Affairs, when those attending the meeting were received by Dr. H. Veldkamp, the Secretary of State for Economic Affairs, who deputised for the Minister, His Excellency Professor-Dr. J. Zylstra.

On Tuesday the delegates were taken to The Hague to see the return procession from the opening of Parliament, by Her Majesty the Queen, and to see some of the pageantry associated with that occasion. While the members attended the reading of papers on Tuesday afternoon, their ladies were taken to Delft to visit the Prinsenhof Museum and the New Church. In the evening of the same day an operatic concert was given in the Rolzaal, Binnenhof, and an opportunity was given to pay a short visit to the Ridderzaal, which was built in 1280 A.D., and where the ceremony of opening the Dutch Parliament had taken place earlier in the day.

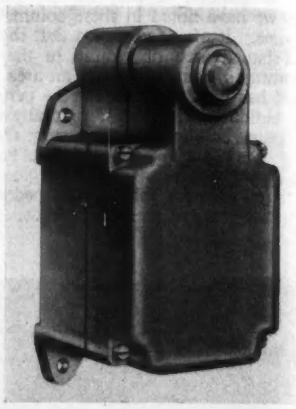
In the morning of the following day the ladies journeyed to Aalsmeer to see something of the Dutch flower centre, and after lunch they went on to Haarlem to visit the almshouses there, and also the Frans Hals Museum, before returning to Scheveningen. On Thursday the whole party set out for Amsterdam as guests of the Amsterdam Shipbuilders and Repairers, where some members went for a tour of the canals and visited the Ryksmuseum, while the remainder were shown round the shipyard and engine shops of the Netherlands Dock and Shipbuilding Company. Later both groups embarked in the excursion vessel "Kasteel Staverden," which went through the locks from the port into the Iyselmeer and then sailed for the island of Marken, where everybody went ashore to visit the island community where ancient costume is still everyday dress. From Marken the ship crossed to the mainland to disembark the passengers at Volendam, where a short stay was made before setting out on the return journey by road.

The Rotterdam Shipbuilders and Shiprepairers acted as hosts on Friday, when a journey was made to Dordrecht, where the members and ladies embarked on two passenger ships to visit the establishment of L. Smit and Son at Kinderdijk, the particular object being to inspect the operation of the optical marking-off system installed there. Afterwards the two vessels parted company, one proceeding to the Rotterdam Dry Dock Company and the other setting course for the Wilton-Fijenoord Shipbuilding Company at Schiedam. Apart from observing the work in progress at the shipyards and engine works, the journey by water was of absorbing interest, revealing as it did the vast amount and great diversity of traffic on these waterways and giving, as the voyage proceeded, many opportunities to see the many interesting and famous ships of to-day and of the past which were in port.

A banquet and dance was held in the evening of Friday, September 18th, at the Hotel Kurhaus, Scheveningen, when the hosts were the Dutch Shipbuilders Association, "Cebosine." This function brought the official part of the visit to a close, and valedictory speeches were made by Mr. J. W. Hupkes, the President of the "Cebosine," by His Excellency, Professor-Dr. J. Zylstra, the Minister of Economic Affairs, and by Mr. L. Neher, who spoke on behalf of the President of the Royal Institution of Engineers, Dr.-Ir. J. A. Ringers. Viscount Runciman of Doxford, the President of the Institution of Naval Architects, returned thanks on behalf of the members of the Institution and their ladies for the excellent programme arranged by the hosts for the autumn meeting and for the hospitality extended to the party by the several Dutch associations of shipbuilders and engineers.

A Ball-Headed Plunger-Operated Limit Switch

WE learn that Brook Motors, Ltd., Huddersfield, has recently introduced a new limit switch ("LS52") with a ball-headed operating plunger. The hardened steel rotating striking ball carried by the plunger enables the mounting position of the limit switch to be independent (in one plane) of the direction of travel of the striker nose. The case, as illustrated herewith, is die cast, the cover being fitted with a rubber gasket



Ball-Headed Plunger-Operated Limit Switch

and secured by captive screws. The overall dimensions of the case are 4 7/16 in by 2 1/16 in by 2 11/16 in with a ½in screwed conduit entry.

Maximum depression of the operating plunger is about 5/16in, the corresponding pressure required being 3 lb. There are two circuits—one make and one break—and to give low resistance heavy silver contacts are fitted. The switch is rated for controlling circuits up to 660V. In the interests of reliability and easy maintenance the number of component parts in the switch has been reduced as far as possible.

Pod Mounting of Jet Engines

By GEORGE S. SCHAIRER*

This paper, which was read last week at the fourth Anglo-American Aeronautical Conference at Friends House, Euston Road, N.W.1, examines the basic problems of pod mounting jet engines, most of which are mentioned in this abstract. It is maintained that such mounting permits engine performance approaching the ultimate, deleterious effects on wing critical Mach number can be avoided, and that the aeroplane structural weight remains good. Secondary advantages are claimed in respect of maintenance, fire risk, aircraft stability and control, and noise reduction.

THERE are many considerations involved in engine mounting. The popular viewpoint gives great emphasis to performance aspects of engine mounting. These performance aspects can be technically divided into aerodynamic performance and structural performance and then combined into the total performance. From the designer's viewpoint at least as great interest lies in the safety and maintenance aspects of an engine installation. These and other considerations are reviewed in the following sections.

Aerodynamic Performance. — Performance aspects of an aeroplane are well described by the Breguet range formula :

$$\text{range} = 750 \frac{L}{D} \frac{\eta}{c} \log \frac{W_{take\text{-}off}}{W_{landing}}.$$

With proper allowances for fuel reserves and other required flight range margins, this old formula works very well in describing the range-payload characteristics of jet aircraft. For purposes of convenience the portion of the formula $(L/D)(\eta/c)$ is used as the measure of "aerodynamic performance," and the term

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"$W_{take\text{-}off}/W_{landing}$" is used as the measure of "structural performance." The aerodynamic term is made up of the conventional term L/D, or lift/drag ratio, and the second term η/c, which is more conveniently expressed for jet engines as the ratio of thrust horsepower divided by fuel consumption in pounds of fuel per hour. The term η/c is nearly proportional to Mach number for jet engines, so the aeroplane and engine can conveniently be studied, by comparisons of $(L/D)\times$Mach number for the aeroplane, and basic engine performance for the engine.

Engine Performance.—Engine performance can be materially changed by installation features. The engine inlet can materially reduce thrust and increase fuel consumption if it does not make available full ram compression and if it includes sizeable losses due to long ducts. Similarly, the engine tailpipe can reduce engine performance if it is long and has high losses. Pod mounting gives the possibility of negligible inlet and tailpipe losses. Such conditions are relatively easy to obtain with a minimum of experimentation. As an example of what the losses can amount to Fig. 1 shows minimum losses

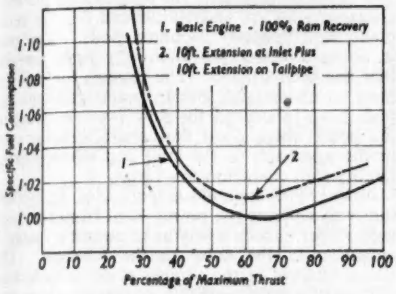


Fig. 1—Engine Performance under Cruising Conditions

possible with installations requiring long inlet and tailpipes compared with a pod mounting. The engine fuel consumption has a direct effect upon the aerodynamic performance. The thrust loss must be compensated by the use of a larger, heavier engine.

Pod Drag.—The most obvious element of aerodynamic performance associated with pod mounting is the drag of the pod itself. Since most pods have a reasonably good fineness ratio, it is not surprising that it is relatively easy to obtain isolated pod drag critical Mach numbers in excess of 0·9 for almost any basic pod arrangement. Wind tunnel tests of isolated pods can be made to determine that there are no separations over the nacelle and that the critical Mach number of both the forward portion and the aft portion are adequately high. In the past, primary emphasis has been given to the critical Mach number of the forward or entering portions of the pod. Most pods have a velocity peak both at the front end and at the rear end, where the flow converges. An increasing velocity results whenever the air is made to turn a corner, and this is equally true for the converging flow to the rear of a pod, as well as for the flow around the nose. Primary emphasis is required to obtain proper converging flow.

Since the pod must be mounted adjacent to the wing, attention must be given to the pod critical Mach number obtained in the presence of the flow over the wing. Fig. 2 shows a typical example of a velocity survey one-quarter chord below a conventional high Mach number wing. It will be noted that there is a large influence of lift coefficient upon the local velocity below the wing and that at low lift coefficients velocities are substantially above free stream velocity over the forward three-quarters of the wing chord.

Notation

b—Aircraft span.
c—Specific fuel consumption.
C_L, C_D—Aircraft lift and drag coefficient.
D—Total aircraft drag.
L—Aircraft lift.
M—Mach number.
V—Aircraft forward speed.
v—Local air flow velocity.
W—Aircraft weight.
η—Propeller efficiency.

A favourable pressure gradient exists near the leading edge and an unfavourable pressure gradient exists near the trailing edge, particularly at low lift coefficients.

When a pod is placed in this velocity field below a wing, major interference effects can be expected. When the pod's contracting air flow requirement is placed in the wing's increasing velocity field a problematical situation exists.

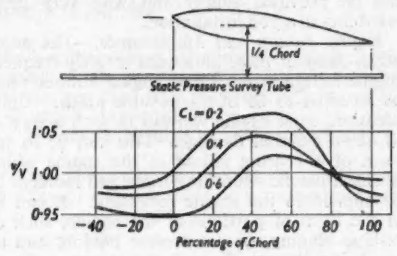


Fig. 2—Local Velocity Variations Below a Wing

Higher velocities are likely to be encountered, but recovery will be effected under more favourable conditions. On the other hand, any attempt at pod flow recovery just forward of the wing trailing edge is likely to be unsatisfactory, because of the combined high velocities and adverse pressure gradient. In most circumstances it can be expected that pod critical Mach numbers will be lowered by the wing flow field at low lift coefficients and possibly increased at high wing lift coefficients.

In such complicated circumstances it is necessary to resort to experimental test data in the design of the pod, its location and support. Typical experimental data are shown in Fig. 3. These data show that both pod location and shape have a large effect upon both basic drag and

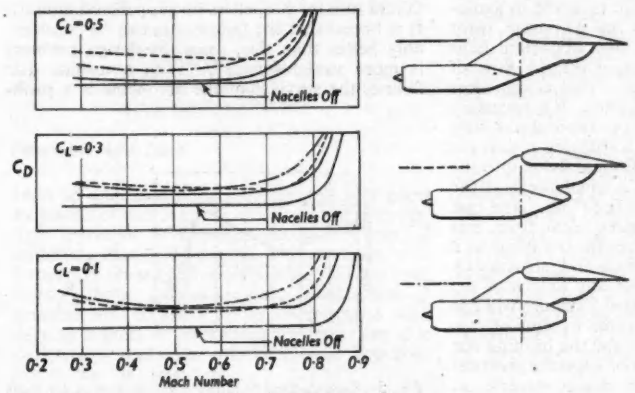


Fig. 3—Typical Pod Drag Data

critical Mach number. The fairing of the back end of the pod and the intersection with the pod mounting strut can be very important. These data are presented as a typical example and not as design data. It will be found that each aeroplane has a different requirement and a different problem which must be solved individually in the wind tunnel. The data of Fig. 3 are presented to show the nature of the problem and that individual solutions are possible. It has been found that negligible losses in critical Mach number are possible with a variety of pod installations, but that it is necessary by actual test to determine a particular solution for each specific case.

Typically, it will be found that the basic pods have an increment of drag of about 18 per cent of the basic aeroplane flat plate drag. Under cruising conditions this represents a 9 per cent reduction in lift/drag ratio. This is the influence upon the aeroplane less power plants and is not the number to use in comparison with submerged installations.

An aeroplane with pod-mounted engines will normally have a considerably higher wing aspect ratio than will be found on an aeroplane with submerged wing engines. Frequently the wing will also have a higher wing loading. Both of these characteristics will result in a smaller tail size and the aggregate effect will be a reduction in flat plate drag ascribed to the wing and tail and a material reduction in the induced drag, as compared with an aeroplane with submerged wing engines.

When combining the various elements of the aeroplane into a complete whole, various counteracting effects are noted. Aeroplanes with pod-mounted engines typically have very low wing drag, both flat plate and induced drag, and have very high values of lift/drag ratio. Since it is actually the maximum value of $(L/D)\times M$ that is of basic interest, the critical Mach number must also be considered. Since this ratio will be a maximum at fairly substantial lift coefficients the pod critical Mach number will seldom be an important factor. When comparing aeroplane types the comparison should be based

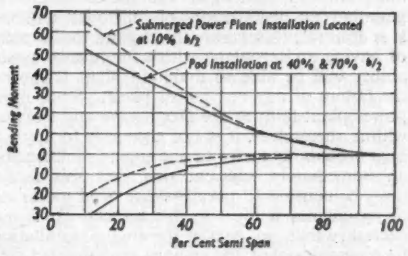


Fig. 4—Comparative Wing Bending Moments with Pods and with Submerged Engines

upon either the maximum lift/drag ratio or the maximum value of $(L/D)\times M$. It is quite a challenge to equal, or better, the values which are possible with pod-mounted engines.

Structural Performances.—Fig. 4 gives an indication of the tremendous influence of pod-mounted engine weight on wing bending moment. It will be noted that for a typical case very large reductions in positive bending moment result from the restoring moments of the engine. The negative bending moments are increased by the engine weights, but only to an amount that can be readily handled by a structure primarily designed for positive bending.

With pod mounting the engine mounting and strut connecting the engine mounting to the wing are externally evident, as also are the cowling and fire walls and so on. It must not be assumed that their weight is greater than the weight which would normally be provided for properly mounting, cowling and protecting the power plant installation with any other type of installation.

It is obvious that no generalised structural performance conclusions can be drawn without a study in great detail of various methods of mounting engines. The structural engineer can become quite discouraged if he takes a statistical approach to this problem. A comparison of structural weight ratios over the past fifty years of aviation shows surprisingly little change in structural weight ratio. All the gain in structural design has been used up in providing additional capabilities. This same trend has appeared in most studies of various methods of mounting jet engines in multi-engined aircraft. The weight ratio remains about the same, but new capabilities in other fields are accomplished. There is no indication that proper wing pod mounting of jet engines has any significant effect, favourable or otherwise, upon the structural performance of an aeroplane as compared with submerged wing root mounting. Of course, pods mounted too far inboard on the wing or on the body will result in a structural penalty with no compensating aerodynamic gain.

Safety.—The use of multiple numbers of engines to increase the safety of an aeroplane will only be successful if the failure of any one power plant will not disable the aeroplane. In other words, increased safety is possible only by

having a power plant which does not endanger the aeroplane in case of its own failure, and then by using enough of these power plants so that the aeroplane can have an acceptable probability of continued powered flight. This requires that the design provides isolation of power plants so that the failure of one is not likely to influence the failure of another. It also requires great attention to the isolation of the power plant from the aeroplane proper, so that the failure of an engine will not in itself endanger the aeroplane.

Normally, the power plants have been separated a sufficient distance so that the probability of mechanical damage from one power plant to another was minimised. It is very important to remember all these factors in planning an installation of turbo-jet engines. It is desirable to separate the engines to the point of having an aeroplane which for normal probability will be able to maintain flight following the failure of any one power plant. Since most power plant failures are progressive and isolated within themselves, it is not necessary to apply a high probability factor to one engine's influencing an immediately adjacent one, but this factor must be considered nevertheless. Pod mounting of jet engines is ideal in this respect. It is not necessary that any part of the engine installation be common unless the engines are mounted side by side in pods. This latter should be done with a minimum of common points and with full realisation that on occasion one power plant will damage the adjacent one. This damage can be minimised for the normal case, but sometimes very serious damage will be encountered.

The most dangerous safety aspect in most modern aircraft is the possibility of fire. The problem is one both of avoiding the existence of a fire and putting out the fire after it exists, since one cannot anticipate and prevent all possibilities of having a fire ignited. A number of fundamental principles are involved in avoiding serious fire problems in a power plant installation. Probably the most important is to provide a method for shutting off the flow of combustible fluids to a fire. This is the most sure-fire way of putting out a fire. It is necessary to keep down the quantity of combustibles in a possible fire zone and also to provide means for shutting off the flow of additional fluids into the zone. This leads towards a small fire and the possibility of having it burn itself out. The pod mounted power plant is most ideal from this aspect. If the shut-off valves for the fluids to a pod are placed in the wing and structurally attached to the wing so that any failure of the pod structure or fire in the pod structure will not damage the valve, it is possible to shut off the fluid to the pod and provide for the burning out of the fire. This has proved of immense practical value in many cases in the Boeing experience. The use of fire-extinguishing gases must be considered, but is of dubious value.

Wherever possible the pod should be isolated from the aeroplane by a sizeable air space. The air space is divided between the air space inside the pod supporting structure and the air space between the external pod surface and the external wing surface. It is desirable to keep the pod structural connection to a minimum. The space inside the structure should be divided into a number of zones, each isolated from each other with proper drainage. Any leaking fuel line must be provided for by ensuring that the zone through which it passes is drained in a safe manner. The question of fire walls with pods becomes somewhat different from the more conventional fire wall in a reciprocating-engine nacelle installation. The fire wall tends to be a defence in depth. Since the primary concern over fire is in flight, where there is an extensive air flow over the structure and over the pod, it is possible to expect considerable cooling and blowing away of a fire in a fore-and-aft direction, rather than a normal vertical envelopment by the fire, as would be expected on the ground. In addition, most jet engines are arranged so that it is possible to isolate the structure around the engine into a number of separate zones, and what might be described as a fire wall is placed between the pod surface and the engine mid-frame or some similar location.

With a fire in the pod, it is sometimes desirable to know how the fire will progress in the pod. This can be provided for by the use of mixed structure, with light structure placed where it is desirable to have the fire proceed. A burn-out patch can be used to permit the fire to burn through the side or bottom of a pod and hence blow itself out in a direction away from the wing or the pod-supporting structure. One of the most important phases of power plant fire protection is in the drainage problem. This can be provided simply and with very great reliability in a pod installation.

Engine Failure and Maintenance.—The aeroplane designer must anticipate a fairly frequent engine failure rate. These engine failures must be assumed to be of all possible kinds. Upon occasion, a jet engine will fail in such a way as to cause external damage. This can be in the form of a bearing failure in the engine which causes a terrific wrenching force and moment to be applied to the engine mounting. It can be in the form of portions of the engine, such as turbine blading, or compressor blading and so on, being thrown through the engine walls or out at the inlet or tail cone of the engine. It is very wise to provide in the basic engine installation for as many and as frequent failures of these kinds as the designer can conceivably provide for. The designer should arrange, if at all possible, that turbine and compressor blading failures result in the blades proceeding forward through the inlet, or out through the tailpipe, and then going in such directions that they do not contact the aeroplane. The inherent flexibility of pod mounting materially reduces the chances of engine mounting failure during seizure of bearings and engine out-of-balance conditions. It is always possible to have a failure of any mechanical part and for this reason it is not possible to dismiss turbine wheel failures or compressor disc failures. This is a design problem in the engine, and failure of these parts can be kept to an extreme minimum comparable with the failure rate for propellers on propellered aircraft. It is hoped that the failure rate can be considerably better than this, since the design problem is more straightforward. With a turbine disc failure, the survival of the aeroplane is a probability case. Will a part of the turbine pass through a vital part of the aeroplane ? A pod-mounted engine has great value in this consideration. Pod-mounted engines normally will have a high percentage of safe possible directions in which parts can be thrown. If a pod-mounted engine fails in such a way as to leave an aeroplane, it results in a minimum of damage to the aeroplane, both from a structural and from an aerodynamic standpoint. The resultant drag of the aeroplane will not be greatly influenced and the structural integrity will be reduced by only a small amount due to loss of the restraining moment.

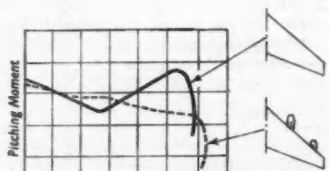


Fig. 5—Longitudinal Stability Contribution of Jet Pods

Pod-mounted engines contribute greatly to the safety of an aeroplane by giving a chance for adequate engine maintenance. This results in reduced failures of the engines and longer hours between difficulties. An engine which is not properly maintained will have a high failure rate. Good engine maintenance can materially reduce the frequency of engine failures and can preclude certain types of failure altogether. Pod-mounted engines can give such good access and maintenance characteristics that the performance in this safety respect cannot be equalled in any other arrangement. Pod-mounted engine installations offer the ultimate in accessory maintenance and change capabilities. It has not been difficult to arrange the accessories in such a way that they do not materially influence the drag of the pod and at the same time to provide exceptionally good access to the accessory and its mounting. This is very important since, in most cases, the accessory choice and installation can be very flexible and can be changed in design when required without conflict with primary structure. The ultimate in accessory mounting is usually possible with pod-mounted engines. This comes about because of the lack of structure near the engine. The engine is held at a minimum number of points with a structure reaching back to the basic wing structure and conflicts of requirements are at a bare minimum.

Stability and Control.—One by-product of the pod-mounted engine has been of inestimable value in the success of highly swept aeroplanes. Wings with high sweep-back have notoriously bad stall characteristics. The stall difficulty shows up as a longitudinal instability as the stall is approached, which results from a rapid stalling of the wing near the tip. This same stalling near the tip represents poor lateral stall control as well. A typical curve of pitching moment against lift coefficient plot for a swept wing is shown in Fig. 5. This same figure also shows the pitching characteristics for the same wing with pod-mounted engines. The longitudinal pitching characteristics are entirely normal for the aeroplane with properly mounted pods. The pod is doing a better job than any fence or slat that has been studied. The reasons for this are hard to understand, but in practical terms the pods have influenced the flow over the wing to the point where good flow characteristics exist in the approach to the stall and entirely satisfactory stall characteristics result.

Noise.—Pod-mounted engines give an opportunity to separate the power plant from the fuselage proper in such a way as to permit a material reduction in the noise in the fuselage. The lateral spacing of the engines gives considerable reduction in noise level due to distance alone and permits even the rear portions of the aeroplane to be useful, since they can lie ahead of the cone of noise of even the inboard engines. With low wing aeroplanes, the wing itself also offers a shield to the noise. Inlet noise has not been identified as a source of difficulty in many installations and is certainly not going to be a problem with pod-mounted engines. The design of the wing structure, including flaps and so on, behind the pod-mounted engine must take full account of the noise level present in these areas. A noise level of 162 decibels is equivalent to an oscillating pressure of 1 lb per square inch. With any type of engine installation, structure is liable to be sufficiently close to the engine to get noise levels of this magnitude, and provision must be made to withstand them. This problem is no worse and probably a little better for pod-mounted engines, compared with other types of installation.

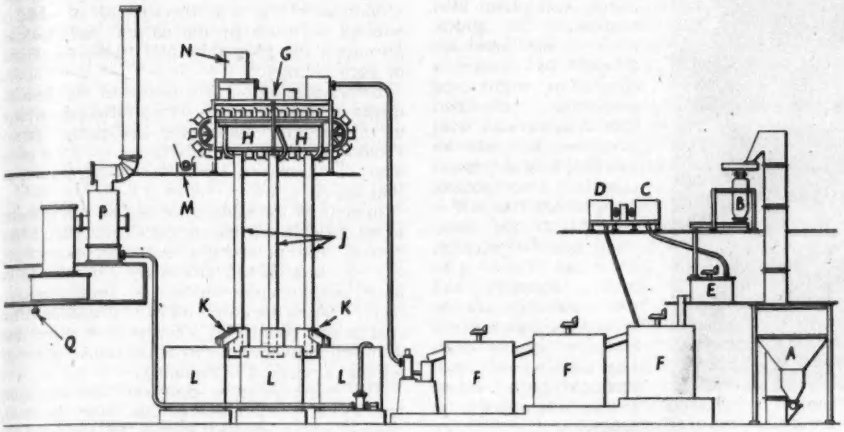
Reverse Thrust.—Widespread use of jet aeroplanes will sooner or later require the use of some means to obtain reverse jet thrust. This requires that the jet be deflected into a forward direction. A deflection of the jet to a 45 deg. angle forward would represent a 70 per cent reverse thrust recovery. This in itself requires the blowing of large quantities of very hot gases forward over the aeroplane. With pod-mounted engines this exhaust gas will contact only the pod and the pod-supporting structure and the deflecting means can be so arranged that the basic wing structure is not involved. Furthermore, the pod type of installation permits ready modification so as to permit application of this reverse thrust, when the mechanisms to accomplish this have been developed.

Cost.—As in many other intangible items, no particular position can be proved on costs, but a logical study of the problem would indicate that pod-mounted engines provided a design which permits an absolute minimum of manufacturing cost. The basic structures of the aeroplane, such as the wing, are very simple and without a lot of special large structural doors and cut-outs and so on. The engine installation can be made as a separate entity and constructed separately from the basic wing structure. Assembly operations can go forward without conflict and, as in the requirements for quick and cheap maintenance, low manufacturing costs can be expected from this type of installation.

A Phosphoric Acid Plant

As part of an extensive modernisation and development scheme at the fertiliser factory of the Farmers' Company, Ltd., Barton-on-Humber, a new phosphoric acid plant has been supplied by the Sturtevant Engineering Company, Ltd. The new plant is based upon the Nordengren dihydrate process and is designed for a capacity of some 25 to 30 tons of concentrated acid per day.

IN order to meet the growing post-war demand for phosphate fertilisers, including triple super-phosphate containing 45 to 50 per cent P_2O_5, the Farmers' Company, Ltd., Barton-on-Humber, early in 1950 decided to undertake a scheme of plant modernisation and development at a cost of some £100,000. Under this scheme a new phosphoric acid plant has been completed, the existing super-phosphate plant has been altered, and the sulphuric acid plant extended.



A—Phosphate bin.
B—Weighing apparatus.
C—Phosphoric acid tank.
D—Sulphuric acid tank.
E—Mixer.
F—Digesters.
G—Tray belt filter.
H—Suction box.
J—Barometric tubes.
K—Drain traps.
L—Filtrate tanks.
M—Gypsum conveyor.
N—Wash liquid tank.
P—Acid concentration plant.
Q—Product outlet.

Fig. 1—Arrangement of Phosphoric Acid Plant

The design and supply of the recently completed new phosphoric acid plant was carried out by the Sturtevant Engineering Company, Ltd., Southern House, Cannon Street, London, E.C.4, and the description which follows is based upon information we have received from that firm. It should be mentioned that Mr. R. B. Risk, of the Farmers' Company, Ltd., and Mr. S. Nordengren, of Sweden, an authority on phosphoric acid manufacture, were closely associated with the Sturtevant Engineering Company, Ltd., in the development of the plant.

The process is based on the Nordengren dihydrate process, and the arrangement of the plant can be seen in the diagram we reproduce in Fig. 1.

The phosphate is ground to a fineness of between 85 per cent to 95 per cent through 100-mesh and is first mixed with a large amount of weak phosphoric acid in a premixing stage. This slurry is then mixed with sulphuric acid of a strength between 65 per cent and 75 per cent. During the reaction the temperature is controlled by recirculating the sludge. Stable dihydrate crystals are formed under a temperature of 80 deg. Cent. and, as the temperature margin is very small for the lower grade of phosphates, close temperature control is of primary importance. After a reaction period lasting from eight to ten hours the sludge is pumped to an acid filter, where the phosphoric acid is removed from the gypsum crystals, part of the acid going as product, part being returned to the system as circulating phosphoric acid. The dried gypsum is diluted and pumped or carried to a disposal dump.

The phosphoric acid plant is housed partly in an existing building which was extensively modified, and partly in a new specially designed building, which also houses the extension to the sulphuric acid plant. The nominal capacity of the plant is 10 tons of P_2O_5 per twenty-four hours, the nominal output of phosphoric acid concentrated to 50 per cent P_2O_5 being, therefore, 20 tons per day. It is, however, anticipated that the actual output will prove to be in the region of 25 tons to 30 tons of concentrated acid per day.

The phosphate is ground in an existing Sturtevant ring roll mill and is transported some 140ft to a storage hopper in the new acid plant by means of one of the firm's air flow conveyors. This conveyor is arranged so that it can, if required, discharge ground phosphate to two hoppers in the superphosphate plant. It has been fitted with an alternative inlet from a second grinding mill to allow for experimentation with varying degrees of phosphate fineness. The side outlets and alternative inlet of this air flow conveyor can be seen in the illustration, Fig. 2. It is interesting to note that the power consumption of this long conveyor is under 1 b.h.p.

The ground phosphate is fed from the storage hopper to an automatic weigher discharging on to a screw feeder which regulates the flow of phosphate to the mixer. This mixer is driven by a variable-speed motor fitted with a tachometer generator, so arranged that any slight variations in the load to the weigher, or of the electric supply is immediately corrected by an electronic regulator. Adjacent to the weigher on the top floor of the digester section are also situated the two acid measuring tanks, which are specially designed rotary feeders, each having a variable-speed drive. The premixer has a lead-lined mild steel vessel with stainless steel agitators. The main reaction takes place in three digesters comprising lead-lined timber tanks with heavy lead-covered agitators and driving gear. The first digester has thermostatically controlled immersion heaters, which serve to maintain a temperature of 60 deg. Cent. to 70 deg. Cent. when the plant is shut down for cleaning and maintenance purposes.

Although it is intended to use high-grade Morocco phosphate in this plant, it may be necessary to use a lower-grade phosphate, in which case trouble can be expected from the formation of froth in the early reaction stage. For this reason a mechanical anti-frothing device has been fitted to beat the froth to a liquid sludge before returning it to the first digester.

The main sludge pump is fitted with an overflow to a standby pump, and these, as well as all other primary pumps, are made in nickel alloy.

The acid filter, which was manufactured in Sweden, is a Nordengren tray belt filter of new design, and it is the first of its kind to be installed in this country. This filter, illustrated in Fig. 3, consists of a series of filter boxes connected up to form a conveyor belt and fitted with stainless steel perforated plates on which are fixed a synthetic filter cloth of a new and improved type. The bottom plates of the filter boxes are connected by a set of rubber pipes to a rubber rope which slides over a suction box. This box is partitioned off according to the filtrate fractions required, and each compartment is connected to a barometric tube which is under 80 per cent vacuum. The bottom ends of the barometric tubes are sealed off in hydraulic closures. The sludge is fed on to the filter boxes by means of a rotary bucket feeder, the speed of which is synchronised with the speed of the belt. As the filled filter boxes come under suction from the first suction compartment the acid is drained off through the tube and overflows from the hydraulic closure into a filtrate tank. As the belt enters the next compartment wash liquid from a following filtrate fraction is fed on to the trays from an adjustable wash box overhead, the last wash liquid being pure water and spillage water from the filter drain. Three or four filtrate fractions are taken from the acid filter; the first filtrate will contain approximately 30 per cent P_2O_5, depending upon the grade of phosphate used and is pumped up to a feed tank connected to the evaporator. The second filtrate, containing 18 per cent P_2O_5, is returned to the process as circulating phosphoric acid in the premixing stage. The third and fourth filtrates, containing from 5 per cent to 7 per cent P_2O_5, are returned to the filter as wash liquid. Vacuum is provided by a rotary exhauster, and a series of lead-lined sealed vessels in the vacuum line

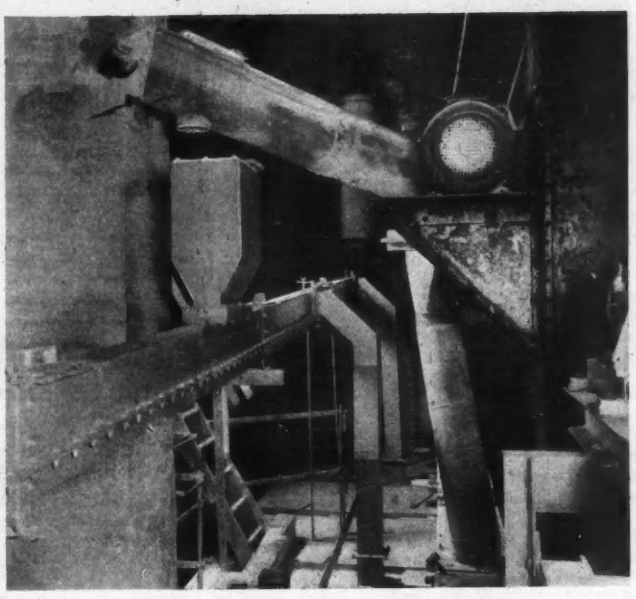


Fig. 2—Section of Air Flow Conveyor

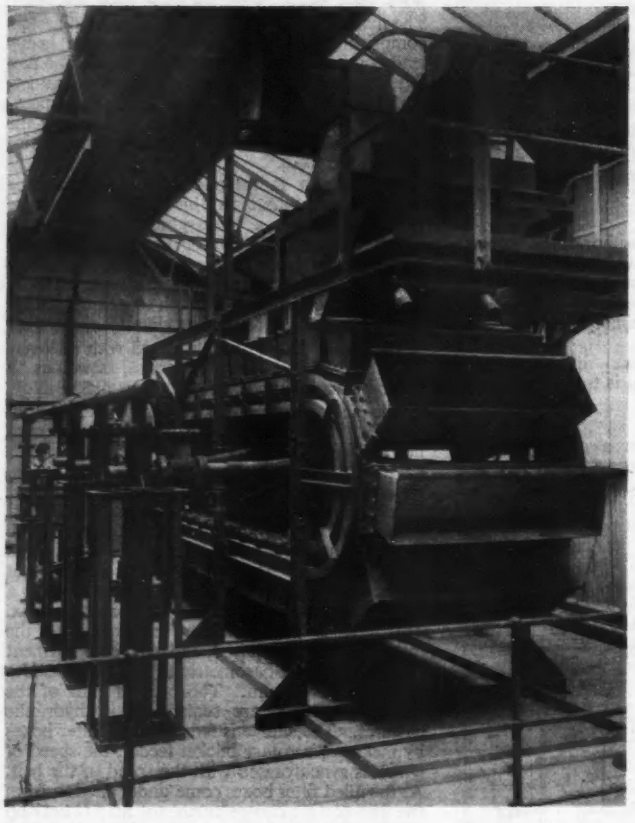


Fig. 3—Tray Belt Filter

ensures that any acid fumes are trapped and neutralised.

The dry gypsum cake falls from the end of the filter into a paddle mixer, where it is diluted with water and gravitates into a gypsum storage tank fitted with a mechanical agitator. Once every hour the gypsum is pumped to a disposal dump approximately ½ mile away and the pipeline is flushed with water.

The evaporator, which was supplied by Nordac, Ltd., includes a pre-evaporator, where the liquid is preheated by means of the waste gases from the main evaporator. The liquid passes from the pre-evaporator through a control valve to the main evaporator, which is a heavy rubber-lined steel tank with an internal lining of acid proof refractory bricks. The main evaporator—see Fig. 4—is fitted with a Swindin submerged combustion chamber using an oil burner which was specially developed for this plant. The combustion flame is released beneath the surface of the liquid giving an almost complete heat transfer. The pulsations in the liquid are utilised to create a circulation within the evaporator chamber. The concentrated acid overflows through an overflow box and gravitates into a storage tank from which the acid is pumped to the phosphate acidulating plant. Fumes from the mixer, digesters and the evaporator are removed through a partly lead-lined timber ducting and are drawn through two wash towers arranged in series.

It is worth noting that this plant has been designed for conversion to the Nordengren anhydrite process, which is a newly developed wet process, and promises to be particularly efficient for phosphoric acid manufacture. This process is, however, still only in the experimental stage, although full-scale plants are now being built on the Continent. The main characteristic of this type of plant is that it can be used for the production of phosphoric acid containing 45 per cent P_2O_5 without the need for concentration.

Fig. 4—Submerged Combustion Evaporator

Years of Transition*

By R. C. BOND, M.I.C.E., M.I.Mech.E.

I PROPOSE to speak on the work in which I have been engaged unbrokenly for the past thirty-three years, namely, the maintenance and construction of locomotives for main line railways, subjects which are, at every turn, inextricably bound up with design, development and operation, and which can never be considered in isolation. The title which I have chosen for my address is "Years of Transition."

A position has long since been reached in which steam, electric or internal combustion traction can all be relied on to meet a wide range of traffic conditions with a high standard of reliability. A decision to make a change in the form of motive power, under any given conditions, cannot, however, be based only, or even mainly, on purely technical grounds. Justification for a change must rest generally upon the economics of the case, the strength of which is affected so much by the natural and financial resources, the geography and traffic conditions of each country.

Before passing on to a review of the developments in steam traction which have taken place in this country during the last thirty years I should like to refer briefly to some of the problems of alternative forms of motive power, as they appear to me.

In spite of the abundance of fuel oil, it seems to me difficult to avoid the conclusion that, under present and prospective economic conditions, our railways should ultimately continue to be based mainly upon the use of home-produced fuel. Unless, therefore, oil can be distilled from coal in this country at a competitive price, coal as mined must continue to be the source of energy for the railways of this country.

The rising price of coal and the increasing scarcity of the highest grades must, however, compel a far-reaching change in the way the fuel is used, and thus encourage a steady trend towards electrification, a trend which will be strengthened by the knowledge that the most practical way of utilising atomic energy for transport will probably be through conversion to electricity. The many advantages of electric traction and its complete ability to meet the most arduous conditions that can be foreseen have long been recognised. The relatively slow progress of main line electrification between the wars has been due primarily to uncertainty of an adequate return on the heavy capital outlay involved.

Since the war the severe limitations imposed upon capital expenditure has curtailed and still curtails the possible rate of progress with electrification. Large schemes are, however, under consideration, which, if authorised, would, even with the present restriction on investment expenditure, impose a heavy burden on the manufacturing capacity available to the home market. The technical staff and designers of British Railways are therefore actively engaged in the development of prototype electric locomotives and multiple unit vehicles in preparation for the time when large numbers will be required.

Whether diesel or gas turbine locomotives, as distinct from railcars, will be able to establish for themselves a position of any substantial importance for main line services in this country is a question not yet finally resolved. Technically they should be able to meet all requirements. But in this country internal combustion locomotives are handicapped on economic grounds. The higher price of oil compared with coal offsets to some extent their high thermal efficiency, and fuel costs per unit of power at the drawbar show no great advantage at present. Repair costs may prove to be less than for steam locomotives, but will certainly be higher than for electric locomotives. And as first cost of construction is at present from three to four times as much as for steam locomotives of similar power it would seem hardly possible for internal combustion locomotives to show a net reduction in total costs except on those main line services where traffic conditions permit their high availability to be utilised to the extent of running three or four times the mileage per annum achieved by

* Presidential address to Institution of Locomotive Engineers, Wednesday, September 23, 1953. Abstracted.

steam locomotives. The small number of main line diesels at present in service are averaging 3500 miles per week, equivalent to approximately 168,000 miles per year on express passenger services, but the number of engine workings which can be arranged to permit such mileages as this is very limited and even more miles per annum are needed to offset the higher first costs.

With the long-term prospects of further electrification, and the steam locomotives we already have, the extent to which the use of large main line internal combustion locomotives, diesel or gas turbine, is likely to be financially profitable on British Railways is, I think, very limited. In direct contrast to this, diesel shunting locomotives with one man only on the footplate are firmly established as a most profitable investment. There would appear also to be most encouraging possibilities of economy in the operation of many secondary services by multiple-unit diesel railcars with underfloor bus type engines.

Although the broad economics of the case have so far compelled the retention of steam traction as the principal form of motive power in this country and new steam locomotives continue to be designed and built, the conditions necessary to establish a more rapid and extensive change to electric and diesel traction in the fields for which each is most suitable have never been more favourable than at present.

Even supposing it were decided to-morrow that the railways of this country were to be turned over entirely to diesel or electric traction, many years would elapse before conversion could be complete. The claims of the export market on the manufacturing capacity of this country, to say nothing of finance, would limit the rate of progress. It is therefore inevitable that steam locomotives must be relied upon to work the bulk of the main line services in this country, both passenger and freight, for a further indefinite period of years, the end of which is not yet in sight. And thus it seems to me essential that, hand in hand with the most vigorous exploitation of the alternative forms of motive power, wherever economic or other justification exists, the development of steam traction in this country should continue without interruption so as to ensure that the costs associated therewith are maintained as low as possible.

As a guide to the lines upon which this final phase of development can most profitably proceed, I propose briefly to review the progress in steam traction in Great Britain, as I have seen it during the past thirty-three years.

There are a number of points of view from which the development of steam traction can be surveyed. I shall deal first with thermal efficiency, the significance of which is not always correctly understood. It is on account of the relatively slow progress and smallness of the gains which have been achieved in thermal efficiency that the steam locomotive has been mainly criticised. If thermal efficiency were the only, or even the most important, factor which a railway administration has to consider in deciding its motive power policy there can be little doubt that steam traction would long since have been displaced.

The ultimate measure of thermal efficiency is the amount of fuel or its equivalent in electric energy consumed per unit of work performed. The normal statistics of coal consumption in pounds per train-mile are influenced so much by extraneous factors which have no connection with the efficiency of the locomotives that they are of little value for gauging the trend in one among the many variables affecting the final result. An appreciation of the trend in thermal efficiency can best be obtained from the results of dynamometer car tests conducted in normal service, under as nearly as possible comparable conditions. Whereas in tests carried out in the years immediately following the amalgamations in 1923 coal consumptions of 4·5 lb to 5 lb per drawbar horsepower hour were representative of contemporary conditions, to-day the comparable figures are 3·0 lb to 3·5 lb. I do not claim that these figures are a precise indication of the relative thermal efficiency of all locomotives in service at the beginning and end of the period under review, but the general conclusion which can fairly be drawn is that for locomotives representative of contemporary design on express passenger service, there has been an improvement in overall efficiency in terms of coal burnt per drawbar horsepower hour of something like 30 per cent. Test results from freight train working show a similar trend.

In the larger modern locomotives boiler efficiency is often not less than 70 per cent when fired at a rate of 3000 lb of coal per hour, which is about the maximum one fireman can maintain. A point, seldom referred to, which hastened the displacement of steam locomotives in America was that the power required could be obtained only by very high rates of combustion made possible by the universal use of mechanical stokers. The resulting low boiler efficiencies of approximately 50 per cent not only increased fuel costs out of all proportion, but also introduced serious maintenance troubles in the firebox and tubes.

At the moderate rates of firing common in this country the locomotive boiler with its firebox surrounded by water in rapid circulation and with high gas velocities through the tubes has always been an efficient steam generator. At comparable rates of firing evaporative performance to-day is very similar to what it was thirty years ago. Indeed, the trend towards higher steam pressure and temperature actually operates to reduce the efficiency of the boiler itself on account of the necessarily higher smokebox gas temperatures which go hand in hand with hotter steam.

Within the limited scope available, however, much has been done to raise the general level of boiler efficiency by a more generous provision of grate area and firebox volume in relation to steam demand, thus reducing the rate of firing and loss due to unburnt fuel. Close attention has been given to the ratio of length to diameter of boiler tubes and to the relative proportions of superheater elements and flue tubes with a view to improving the efficiency of heat absorption. At any given rate of working, however, throughout the whole power range, it is the small percentage of the heat passed forward to the cylinders which is turned into useful work that mainly accounts for the low thermal efficiency of the conventional steam locomotive as we know it to-day ; and it is to improvement in cylinder efficiency that credit must largely be given for the substantial increase in overall efficiency which has been achieved.

What are the developments in design which have enabled these improved results to be obtained ? The most readily discernible change, affecting thermal efficiency, has been an increase in boiler pressure from 160 lb to 180 lb per square inch to about 225 lb to 250 lb per square inch.

Concurrently with, and more important than, the increase in boiler pressures, there have been radical improvements in the design of valves, valve gears, steam and exhaust ports, and in the draught producing arrangements, the importance of which did not seem to be generally recognised until after the locomotive exchanges on the L.N.E.R., G.W.R. and L.M.S.R. in 1925 and 1926.

The outstanding development has been the universal adoption of long travel gears or, more correctly, of long lap valves, which by permitting the use of early cut-offs without restricting the freedom of exhaust, have reduced appreciably the losses in power and efficiency arising from back pressure and throttling at admission and exhaust. Losses due to steam leakage have been much reduced by improvements in the mechanical design and lubrication of the pistons and valves themselves. Steam pipes, ports and exhaust passages have been made larger in relation to the cylinder volume and much more direct. The unavoidable pressure drop between boiler and steam chest has thus been minimised and back pressures and throttling losses have been still further reduced.

All these developments in design amount to a substantial increase in the capacity of the circuit through which the steam passes on its way from the boiler to the blast pipe. And thus to-day the actual cycle efficiency approaches much more closely to the maximum theoretically possible at the chosen admission and exhaust conditions than was previously the case.

Taking the case of a normal locomotive costing £20,000 to build, running 60,000 miles per year and burning an average of 50 lb of coal per mile, and comparing it with one costing 50 per cent more to build and 20 per cent more to maintain, it will be seen that at the same annual mileage the more expensive locomotive must save more than 25 per cent of fuel for a net financial advantage to accrue. Taking into account the fuel required for steam raising, and burnt during standby periods or when coasting, the actual economy under power must be appreciably greater than 25 per cent.

The disappointing results which have attended the efforts to break away from normal lines of development in this country are typical of experience generally. Nowhere in the world has the motive power situation been substantially affected by the experiments with unorthodox steam locomotives. Though the knowledge gained has, in my view, more than justified the time and money spent, the right policy under present-day conditions is to concentrate on perfecting the mechanical design and operating features of the simple locomotive.

So long as minimum total cost in relation to work done remains the ultimate criterion, thermal efficiency by itself must be viewed in proper perspective as one only among the many factors which must receive consideration. Although the thermal efficiency of a diesel is three times, and of an electric locomotive twice as much as that of the conventional steam locomotive, the ratio of their fuel costs per unit of work at the drawbar is much smaller and the margin available to the complex and expensive steam locomotive of unorthodox design is altogether too narrow for it to be able to compete effectively either with diesel and electric locomotives or with steam locomotives of normal design.

Many of the improvements in design which have resulted in high thermal efficiency have, at the same time, enabled greater power to be developed per ton of locomotive weight. The demand for greater power and speed had been insistent and showed no sign of reaching finality when the war put a stop to further development, the full tide of which is only now beginning to flow again.

In addition to the effect which long-lap valves of adequate diameter have had on thermal efficiency, they have also contributed much to increased power by raising the mean-effective-pressure/speed curve. But the key to the whole situation, upon which all else depends, is the ability of the boiler to deliver the steam required. A good steaming boiler can cover a multitude of sins—one that will not steam will rightly blacken the reputation of any locomotive. And thus a great deal of attention has been paid to boiler proportions, especially free area through the tubes and draught arrangements to ensure the maximum flow of air and products of combustion upon which good steaming largely depends.

I will now turn to a brief consideration of what has been done to reach a higher level of mechanical and operating efficiency. Improvements in design, materials, equipment, and particularly in organisation at works and running sheds, have all contributed to the progress made, the final measure of which is higher availability and more intensive use, fewer locomotives and lower maintenance costs.

Nearly one-third of the 19,000 locomotives of British Railways are to-day suitable for, and used quite impartially on, a very wide range of services. And to them should go the credit for a large part of the increase of 25 per cent in the miles per day per engine in use, which is typical of what has been achieved in this respect.

The operating department has not only been given a steadily rising proportion of locomotives capable of intensive use, but, in addition, the hours per day during which they can be so used have been substantially increased.

There has been a notable reduction in the percentage of locomotives out of service for repairs at works and motive power depots. In 1923 there were no less than 16·86 per cent of the locomotive stock under or awaiting classified repairs. At the end of last year the comparable figure was 5·02 per cent.

I can do no more than touch very briefly on some of the main factors which have contributed to these results. In the motive power depots mileage and periodical examinations in combination with systems of preventive maintenance have reduced the time out of service for running

repairs. Chemical treatment of many of the worst scale forming and corrosive water supplies has eased the burden of boiler examinations and maintenance at the sheds and works and has allowed the periods between washing out and firebox examinations to be extended. Limits have been set to the extent of repairs which should normally be undertaken at motive power depots, the heavier jobs which would at one time have been considered appropriate to running sheds now being done at the works in much less time.

In the locomotive works the whole conception underlying the organisation and progress of repairs has been fundamentally changed. Instead of repairs being planned in conformity with the progress of work on the boilers, which takes longer to complete than any other major component, the guiding principle has been to reduce the time and thus the number of locomotives under repair to the lowest possible limit. Spare boilers enable repairs to be completed without interruption and all the principles of production engineering have been applied with conspicuous success to the task of accelerating output of repaired locomotives. In the result the average time to complete a general repair has been cut by at least 50 per cent, notwithstanding the increase in the size of locomotive and reduction of weekly working hours which have occurred over the same period.

Finally, availability has been improved and maintenance costs substantially reduced by the far-reaching policy of standardisation carried into effect by the four main line companies between 1923 and 1948 and which is now being vigorously pressed to its logical conclusion.

Two points seem to me clearly to emerge from our experience with steam traction during the past thirty years. First, progress has mainly been achieved by concentration upon perfecting the design, operation and maintenance of the fundamentally simple locomotive ; and secondly, finality has not yet been reached in the efficiency of the contribution which steam traction must make to the solution of our rail transport problems through the further years of transition still ahead, during which the other partners in the motive power confederation will play an increasingly large part. An important consideration here arises as to the extent to which new steam locomotives should be built concurrently with a progressive change in the kind of traction.

If it be conceded that everything should be done to ensure that steam traction should be as efficient and economical as possible so long as it remains, along what lines can development most profitably be directed ?

So far as design is concerned, all experience so far points to the fact that the large increase in thermal efficiency, which theoretical considerations suggest should be attainable by the use of much higher pressures or by condensing, cannot in fact be realised on locomotives without too great a sacrifice of reliability and an increase in total costs. Nevertheless, it is not unreasonable to expect an improvement in thermal efficiency from the present average level of about 5 per cent to 7 per cent if, by the normal process of replacement of the older locomotives, the stock includes a steadily increasing proportion of modern types. This is a relative improvement of 40 per cent, and if it be assumed that only one-half of the potential economy could be turned to good account in daily service on a number of locomotives equal to one-third of the present stock, the reduction in coal consumption would amount to nearly 1,000,000 tons per annum.

The largest single source of further economy in steam traction costs is in reduction of expenditure on maintenance in shops and sheds. Although the average mileage between repairs in works has increased by nearly 30 per cent during the last thirty years, there is considerable scope for further improvement. The average mileage between consecutive general and intermediate repairs for all steam locomotives is approximately 65,000 at present. But many of the most modern types, both large and small, are proving themselves capable of running more than 100,000 miles before requiring heavy repairs in the shops.

Earlier in this address I expressed confidence in the future of our railways, and I will conclude on the same note. It can, I think, fairly be claimed that so far, at any rate, progress in all the fields of endeavour which go to make up locomotive engineering, in the widest sense in which it is defined in our articles of association, has been solid and continuous.

I suggest that, however far one peers into the future, no form of transport can yet be discerned which will supplant railways as the backbone of the transport system in this highly industrialised country. I suggest that the end of the railway age is not yet remotely in sight. On the contrary I believe, granted a continuing improvement in the economic situation and freedom from external disturbing forces, the railways will be able to reach a new high level of efficiency in the bulk transport of freight and passengers over the main trunk routes.

Buckling and Stability

THE forty-first Wilbur Wright Memorial Lecture was read on Monday of last week, September 14th., before the Royal Aeronautical Society, at the Royal Institution, Albemarle Street. The lecture was entitled "Buckling and Stability" and was given by Professor N. J. Hoff, head of the department of aeronautical engineering and applied mechanics at the Polytechnic Institute of Brooklyn. A detailed account of the behaviour of both slender and short struts was given in the lecture. Professor Hoff noted that the first theoretical calculations of the stability of struts were published by Euler 209 years ago. It was a fortunate coincidence from the standpoint of practical applications, but perhaps unfortunate for the development of a more accurate theory, he said, that the column test carried out in a routine manner in an ordinary testing machine gave results in excellent agreement with the classical theory when the column was slender. The maximum load observed in the test was the same as the Euler load and it was maintained for a considerable length of time while the loading head was moving downward. But the situation was different with short columns whose buckling stress exceeds the elastic limit of the material. They reached a maximum value of the load, Professor Hoff continued, after which the load dropped gradually, or with a sudden snap, depending on the properties of the testing machine. The maximum value of the load was always considerably smaller than that predicted by the Eulerian theory ; its calculation had been the subject of many excellent technical papers in the past sixty odd years.

There were even greater deviations from the behaviour predicted by the classical theory than that observed with the short column, Professor Hoff maintained. The thin-walled circular cylindrical shell, he observed, would collapse catastrophically under a load amounting to only one-third of the classical limit of stability ; the simply supported flat plate could be subjected to loads exceeding the theoretical stability limit by a factor of ten or more if it were thin ; in a very rapid test the ordinary column could support a multiple of the critical load ; and an aluminium alloy column maintained at a uniform temperature of 500 deg. Fah. would collapse, with a snap, under any compressive load, however small, if the test were continued long enough.

Professor Hoff gave these illustrations to show how manifold column behaviour could be under various conditions of loading. Many features of the buckling process could not be explained, he said, on the basis of the classical concept of stability, so that other means had to be found to satisfy the needs of the practising engineer, and particularly those of the aeroplane structures man who had to guarantee the safety of the structural elements of supersonic aircraft when they were subjected to high temperatures and rapidly varying loads.

The purpose of his lecture, he said, was to present a detailed investigation of the behaviour of both slender and short columns in the ordinary column test and to correlate the buckling loads obtained in the test with the critical loads of the classical theory. In addition, he discussed the effects of rapid load application and of creep at some length. Experiments were described which had been conducted to confirm some of the conclusions of the theory. The history of the development of the theory of stability was sketched and some of the significant features of the buckling of plate and shells were mentioned. Professor Hoff suggested that a clear distinction be made between the critical load obtained from a stability analysis in which the load had a prescribed value, and the buckling load under which a compressed element collapsed in service under varying loads or buckles in a loading test.

Professor Hoff concluded that a short column compressed in the testing machine with the distance between its two ends fixed could be stable when the disturbance was small, and unstable when the disturbance was large ; consequently it might buckle before its stability limit was reached in the sense of the classical small-deflection theory. A column whose material was subject to creep was unstable, he affirmed, under a compressive load of any magnitude, but it might not buckle during the lifetime of the structure of which it was a part. Buckling under a static load following a disturbance had many aspects differing significantly from buckling during a loading process, he noted, particularly when the latter was rapid, and there were material differences between the various kinds of loading processes.

For these reasons it was desirable, he continued, to distinguish between the stability of a fixed system in the classical sense and the stability of a loading process. There was no reason to believe that an arbitrarily chosen loading test would furnish values that could prove or disprove the classical theory of static stability. There was even a great deal of arbitrariness connected with the definition of the buckling load in a loading process. It seemed advisable, Professor Hoff said, to reserve the terms critical load and characteristic value of the load for the designation of theoretical loads at which the state of equilibrium was of a special character.

Twickenham Refuse Disposal Works

A REFUSE disposal works which, when completed, will serve the urban districts of Twickenham, Sunbury and Staines, is at present under construction at a site adjacent to a number of old gravel workings at Sunbury-on-Thames. The works will embody a modern installation of plant, arranged as a tipping house, followed by a salvage house and, finally, an incinerator house. It has been designed to handle 175 tons of refuse in an eight-hour shift.

At the present time construction is in a fairly early stage, and none of the plant is yet installed. Barrel vault roofing is to be constructed for the three principal buildings and four of the seven vaulted bays of the incinerator house have now been built. Each bay spans 33ft and has a width of 20ft 6in, the radius being 15ft and the shell thickness 2½in. The shell roofs of the other buildings will be larger, the tipping house being covered by a single vault spanning 90ft by 30ft wide and with a radius of 25ft. We were recently invited by Blaw Knox, Ltd., to visit the site at Sunbury, where that firm's "Hico" system of centering is being used in the construction of some of the barrel vaults. This centering system was described in our issue of November 16, 1951, and it may be recalled that it employs lattice-braced units which can be connected together by a hinge at the flat top of the units and a turnbuckle at the bottom, to form falsework beams. In the adaption for a barrel vault, the falsework units follow the curve of the arch in a series of chords ; a special connecting piece is placed between each "chord" unit to obtain the necessary angle between them, and the curve of the arch itself is obtained with a timber turning piece resting on the falsework unit. In this case the falsework arches are at 3ft centres, and they are supported at the springing and the crown of the arch on steel scaffolding. The assembly thus formed can, we understand, be simply erected and is particularly convenient for striking on completion of the work.

The refuse disposal works are being constructed under the direction of the Twickenham borough engineer and surveyor, and the contractor is William Moss and Sons, Ltd.

Industrial and Labour Notes

Overseas Trade

The Board of Trade has now published its final figures relating to the United Kingdom's overseas trade in August. They show that the value of exports of United Kingdom goods was £198,200,000 and that imports were valued at £249,300,000. The value of re-exports was £8,800,000, so that the excess of imports (c.i.f.) over total exports (f.o.b.) was £42,200,000.

The decrease in the export figure when compared with July is, of course, largely accounted for by the influence of holidays on industry and by the shorter month, there being twenty-five working days in August, against twenty-seven in July. If the two months, July and August, are considered together, however, the average value of exports was £216,300,000, or 3 per cent above the monthly average for the second quarter of this year and 4 per cent higher than the average for the first quarter. Furthermore, it is estimated that the increased value of July and August exports has resulted wholly from an increase in volume. Imports in July and August averaged £269,100,000, which was 5 per cent below the monthly rate in the first half of this year and 2 per cent lower than in July and August last year. The volume of imports in July and August has been estimated as about 3 per cent below the level of the first half of the year. The Board of Trade says that the slightly higher rate of export and the reduction in the value of imports reduced the trade deficit in July and August to £44,100,000 a month, which was well below the level of either of the two preceding quarters.

The greater part of the increase in exports in July and August was in the textile groups. In engineering products, smaller exports of cars and machinery caused a drop of £2,000,000 a month below the average of the second quarter. Coal exports, which decreased between the first and second quarters of this year, fell by a further £600,000 a month in July and August, but there was a rise of £1,000,000 a month in shipments of refined petroleum and in the exports of metals. Although full details of the area pattern of the United Kingdom's trade are not yet available, provisional estimates indicate that the improvement in the rate of export in July and August compared with the second quarter was almost wholly in exports to the sterling area, which rose by about 6 per cent between the two periods. Although exports to Australia in August are believed to have been below the July level, the average for the two months was about 20 per cent above that for the second quarter. The Board of Trade says that exports to the non-sterling area in the two months were only slightly greater than in the second quarter.

Railway Wages Claim

During last week it was announced that the Railway Executive had rejected two claims for a 15 per cent increase in wages which were put forward recently by the three railway unions. The first claim was made, on behalf of about 566,000 employees on British Railways, by the National Union of Railwaymen, the Associated Society of Locomotive Engineers and Firemen, and the Transport Salaried Staffs Association. The other claim was put forward by the N.U.R. and the Confederation of Shipbuilding and Engineering Unions on behalf of the employees in railway workshops. It is understood that in refusing the claims, the Railway Executive explained that insufficient progress had been made with measures to achieve greater efficiency on the railways and that the additional financial burden, if the claims were met in full, would almost certainly mean higher fares and freight charges. Last Tuesday, the first claim was discussed at a meeting of the Railway Staff National Council, which is the second stage of the railways' negotiating machinery.

The Employment of Elderly People

In the course of a speech at Guildford last week, the Parliamentary Secretary to the Ministry of Labour, Mr. Harold Watkinson, referred to a forthcoming report from the national advisory committee which had been set up to consider the employment of older men and women. The committee, he said, brought together representatives not only of Government departments, but of the British Employers' Confederation, the Trades Union Congress, and the nationalised industries, and also scientific and welfare experts.

Mr. Watkinson went on to say that, in the last forty years, the number of older people in our population had grown much larger and it continued to get larger still. It had been estimated that by 1962 the number of people between twenty and forty would show a marked fall compared with the present, but the number between fifty and sixty would have gone up by nearly one-fifth. The employment of older people, Mr. Watkinson continued, was essentially a human problem, but it was necessary to consider the consequences of the changes in the age structure of the population. First of all, there was the effect on industrial production, for when people retired their production was lost, and if our national production fell short of what it might be, then the national standard of living would also fall. Then, Mr. Watkinson urged, the experience and long-practised skill which older people could bring to their work should be remembered. To-day, it was not only a question of quantity of production, important as that was, for in overseas trade we were now in a more competitive world where quality turned the scale. This country's traditional craftsmanship and skill were vital assets which, Mr. Watkinson said, must be maintained and developed, and in these more competitive times we could not afford to waste the reserves of skill which older workers possessed.

Most people, Mr. Watkinson continued, could work to a higher age and many of them did. Many more, he thought, would like to do so, but were prevented by the rigidity of our traditional attitude to age, and that traditional attitude was the main general obstacle which must be overcome. It was the fundamental cause of the particular practical difficulties which stood in the way of more employment of older people. Another obstacle, Mr. Watkinson commented, was engagement and promotion policies. Sometimes the nature of the work or other special factors meant, of course, that preference must be given to younger people in filling vacancies. But often, he suggested, upper age limits were not necessary. Sometimes, Mr. Watkinson added, genuine difficulty did arise where the engagement of older people from outside blocked the promotion of younger people within, but he felt that that was a problem which might be over emphasised, and in many sorts of work it did not arise. Industry, he said, must be realistic about it, and each firm or organisation must work out its own solution in the light of its own particular circumstances.

Films in Industry

This week the seventh annual congress of the International Scientific Film Association is being held in London. It was opened officially last Friday evening by the Minister of Labour, Sir Walter Monckton, Q.C., who stressed the importance to industry of films dealing with research, education and training. Sir Walter said that new methods of production, new processes and new and complicated machines were providing the means of greater and more efficient production in many branches of industry. If the full benefits of those developments were to be obtained, it was essential that information about them should be exchanged on the widest possible scale. Films, he considered, had an important part to play in that matter and in the training of the skilled workers which industry required.

During the congress, which ends on Sunday, more than 100 scientific, industrial and other educational films from all parts of the world are being screened. The programme includes also discussions on many aspects of the preparation and use of scientific and industrial films.

Industrial Equipment Exhibition in Montreal

The Foremen's Club of Montreal is arranging the fourth Industrial Equipment Exhibition, which will be held from November 9th to 13th in the Show Mart Building, Berri Square, Montreal. This year, it is stated, there are to be many new exhibitors from Great Britain and other European countries as well as from Canada and the U.S.A., and the Montreal Materials Handling Show is to be combined with the exhibition. The space required to display the exhibits is about 75,000 square feet. The exhibition is intended primarily for foremen and plant engineers. Full particulars of it can be obtained from Mr. E. M. Wilcox, 4585, Sherbrooke Street West, Montreal.

The Training of Foremen

The Industrial Welfare Society is arranging a course which emphasises the value of discussion groups as an effective means of training foremen. This course is to extend over four Monday evenings, November 16th, 23rd, 30th, and December 7th, each meeting beginning at 6 p.m. and lasting about an hour and a half.

Small groups will be guided by experienced discussion group leaders, and the discussions will be based on actual case studies depicted by film strips which have been prepared by the Society. It is stated that the aim of the discussions will be to build up an enlightened attitude on the part of foremen to human relations at work, for it is felt that only on such a foundation can the principles and practice of sound supervision be established. Past experience has convinced the Society that group discussion for foremen possessing varied practical experience is an effective method of improving supervisory skills.

Particulars of the course are available from the Industrial Welfare Society, Robert Hyde House, 48, Bryanston Square, London, W.1, at which address the meetings are to be held.

The Coal Position

This week the National Coal Board has issued its statistical statement setting out the costs of production, proceeds and profit in the collieries and ancillary undertakings in the second quarter of this year. The quantity of coal sold by the Board during that period amounted to 51,849,729 tons, of which 48,281,612 tons were disposed of commercially. The total costs of production were £153,538,287, and the proceeds of sales came to £159,846,474, so that the quarter's profit, before charging interest, was £6,308,187. To that sum, the Board adds £430,000 as the estimated profit on opencast working and £300,000 as the estimated profits of its ancillary undertakings.

The Board's trading profits for the quarter are thus shown as £7,038,187, from which a sum of £2,180,000 is deducted as provision for taxation and interest payments. The estimated net profit was therefore £4,858,187, from which sum a deduction of £4,050,000 is made as the estimated interest payable to the Minister of Fuel and Power. The Board's estimated surplus for the quarter thereby becomes £808,187. The figures relating to costs show that wages, including holiday pay and allowances in kind, required a sum of £96,470,393, and that roof supports, general stores and repairs took up £25,988,283. The average cash earnings of miners during the quarter were £10 18s. 9d. a week for all workers, the average earnings of all underground workers being £11 11s. 4d.

The latest figures for coal production, issued by the Ministry of Fuel and Power, show that last week's saleable output, which includes both deep-mined and opencast coal, was 4,491,400 tons. The total output in the first thirty-seven completed weeks of this year was 156,036,000 tons, which was about 2,500,000 tons less than the amount of coal raised in the corresponding period of last year.

Notes and Memoranda

Rail and Road

NEW RAILWAY APPRENTICE TRAINING SCHOOL.—Mr. R. A. Riddles, member of the Railway Executive for mechanical and electrical engineering, who started his career as an apprentice at Crewe locomotive works in 1909, visited the works on Tuesday, September 22nd, to lay the foundation stone of the new training school. This school, which adjoins the locomotive works, is the biggest of its kind on British Railways, and will supply the locomotive and other technical departments with some 270 apprentices each year. Boys will join the school at the age of fifteen and during the year they spend there will have preliminary practical and theoretical instruction to fit them for the work in which they will specialise during the completion of their apprenticeship.

INSTITUTION OF LOCOMOTIVE ENGINEERS' AWARDS.—At the general meeting of the Institution of Locomotive Engineers on September 23rd, the retiring president, Mr. C. M. Cock, in completing his year of office, made the Institution's annual awards. The Gold Medal of the Institution was awarded to Mr. R. A. Riddles for his outstanding services to the advancement of locomotive engineering. The Frederick Harvey Trevithick award of £30 was made to Mr. R. C. Bond for his paper entitled "Organisation and Control of Locomotive Repairs on British Railways." An Institution award of £20 was made to Mr. W. C. Ikeson for his paper on "The Development of the Oil-Fired Locomotive." The Charles S. Lake award of £10 was presented to Mr. A. W. J. Dymond for his paper "Operating Experiences with Two Gas Turbine Locomotives." An Alfred Rosling award valued at £5 was presented to Mr. A. S. Robertson for his paper "Limitations of Acceleration and Braking with Electric Traction," and another to Dr. H. I. Andrews for his paper "Stresses in Locomotive Coupling and Connecting-Rods." A Stewart Dyer award of £10 was made to Mr. N. Micklethwaite for his paper "Distribution of Fuel on British Railways with regard to Coal and Coke," and another of £5 to Mr. R. E. Morgan for his paper "Development of the Farnborough Indicator and its Application to Steam Locomotives." The President's Prize was awarded to Mr. E. L. Byrne for an essay on the Institution's visit to the works of the Pressed Steel Company at Cowley in March last. Abstracts from the address of the new president, Mr. R. C. Bond, appear on another page in this issue of THE ENGINEER.

Air and Water

I.C.A.O. APPOINTMENT.—The Ministry of Civil Aviation states that Sir Frederick Tymms, K.C.I.E., is to retire from the post of United Kingdom representative on the Council of the International Civil Aviation Organisation in January, 1954, and will be succeeded by Mr. J. E. Keel who is at present Under-Secretary (Safety and General), Ministry of Civil Aviation. Mr. E. A. Armstrong, C.B., at present Principal Establishment Officer, Ministry of Civil Aviation, will succeed Mr. Keel as Under-Secretary (Safety and General) in the Ministry of Transport and Civil Aviation.

B.O.A.C. ANNUAL REPORT.—The annual report of British Overseas Airways Corporation for 1952–53 was published this week. It discloses a profit of £103,875 for this period, the first year of its operation without a Government grant, as against the preceding year's profit of £1,233,722, when a grant of £1,500,000 was allowed. The report recalls several adverse influences during the year and amongst them it notes increases in fuel cost due to the Abadan incident, increased wages, a significant drop in mail revenue, the temporary failure of its "Stratocruiser" fleet, the effects of fog and a general slowing down of world trade. To such factors the report attributes the increase in operating costs from 38·8d. to 40·1d. per capacity ton-mile, and although total revenue rose from £33,567,862 to £36,156,579, the load factor achieved dropped from 65·7 per cent to 64·5 per cent. The two outstanding events of the year, the report recalls, were the introduction of the "Comet" into service and the start of tourist services on the North Atlantic route. The report also records that between July, 1948, and the end of the financial year under review there has been no accident involving fatality or serious injury to any B.O.A.C. passengers.

H.M. SURVEY SHIP "CHALLENGER."—When H.M. Survey Ship "Challenger," which was commissioned early this year for a series of cruises in the eastern half of the Atlantic, arrives at Portsmouth on September 30th, she will pay off and reduce to reserve after completing a long career of surveying and oceanographical research. Prior to her last commission the ship had made a 75,000-mile voyage round the world which lasted two and a half years, and during which she made the deepest sounding ever recorded of 5940 fathoms. This was in the Pacific Ocean at a point only 50 miles from where the old "Challenger" obtained her deepest sounding of 4475 fathoms. The "Challenger," which is the eighth ship to bear the name in the Royal Navy, has a length overall of 220ft by 36ft beam, a displacement of 1140 tons, carries a company of ninety-eight officers and men, and is propelled by triple-expansion machinery of 1200 i.h.p. She was built at Chatham Dockyard as a fishery research vessel in 1931, but was taken over by the Admiralty, and since 1932 has been continuously employed on surveying and oceanographical duties in all parts of the world. The "Challenger" cruise of 1862–76 made history when she returned with the first comprehensive collection of deep sea samples and soundings, and the present "Challenger," with her modern equipment, has been able to fill in the gaps and add to the knowledge gained by the older ship.

Miscellanea

MR. PERCY BUTLER.—As we go to press we learn with regret of the death of Mr. Percy Butler, B.Sc., M.I.E.E., which occurred at his home in Edinburgh on Monday last, September 21st. Mr. Butler was a director and joint general manager of Bruce Peebles and Co., Ltd., Edinburgh.

TUNGSTEN ORE PRICES.—The Ministry of Materials has announced that as from September 16th its selling price for tungsten ores of standard 65 per cent grade and ordinary quality has been reduced as follows:—Wolframite from £16 7s. 6d. to £15 10s., and scheelite from £15 12s. 6d. to £15 per long ton unit delivered consumers' works.

T.D.A. STATISTICAL YEARBOOK.—The Timber Development Association, 21, College Hill, London, E.C.4, has published a second edition of its "Statistical Yearbook" for 1952, which contains eight additional tables showing the sources from which the United Kingdom drew its supplies of timber and wood products in the years 1938, 1951 and 1952.

DUNFERMLINE POWER STATION EXTENSION.—The British Electricity Authority has received the consent of the Minister of Fuel and Power to the extension of the Dunfermline power station by one 12·5MW turbo-generator set and two boilers, each having an evaporative capacity of 80,000 lb of steam an hour. The present installed capacity of the station is 13MW.

NON-METALLIC MAGNETIC FERRITES.—A forty-six-page illustrated booklet entitled "Ferroxcube" has been published by Mullard, Ltd., Century House, Shaftesbury Avenue, London, W.C.2, to give a brief account of the development, properties and uses of non-metallic ferrites, as represented by the material known as "Ferroxcube." In recent years these ferrites have been adopted increasingly as core materials for inductances and transformers.

"PERMANENT MAGNETS."—A sixty-four-page illustrated booklet, "Permanent Magnets," has been issued by Mullard, Ltd., Century House, Shaftesbury Avenue London, W.C.2. Besides giving information about Mullard permanent magnets, it contains comparative characteristics of all commercially available permanent magnetic materials. Reference is also made in the booklet to the magnetic behaviour of the commercial irons and steels normally used in conjunction with permanent magnet alloys.

THE I.E.E. INCORPORATED BENEVOLENT FUND.—The annual report of the Court of Governors of the Incorporated Benevolent Fund of the Institution of Electrical Engineers is being circulated to all members of the Institution with the September number of the *Journal*. The report shows that the total subscriptions have increased from £11,245 in 1951/52 to £12,155 in 1952/53, whereas in the previous report a decrease of £1800 from this source had been recorded. Nevertheless the report points out that the expenditure of the fund exceeded the income from subscriptions by £278, and the Court of Governors appeals strongly for support, particularly from the two-thirds of the membership who do not, at present, subscribe; it is emphasised that a subscription of only 5s. from those members would result in an increase of £5000 in revenue.

DEUTSCHE VERBAND FUR SCHWEISSTECHNIK E.V.—A special meeting of the Würtemburg-Baden section of the Deutsche Verband für Schweisstechnik has been arranged to take place in Mannheim from Thursday, October 15th, till Saturday, October 17th. On the Thursday evening there will be an informal reception dinner at the Rosengarten Restaurant, Mannheim, at 7 p.m. On Friday morning at 9.15 a.m. the president will welcome the members and guests in the Mozart Room of the Rosengarten and will introduce the technical session, which will include the reading of five papers dealing with shrinkage and shrinkage stresses and their practical effect in welded metal constructions. In the afternoon, at 3 p.m., there will be a general discussion on all the papers, and in the evening, at 8.15 p.m., a jubilee dinner will be held to celebrate the twenty-fifth anniversary of the founding of the Mannheim branch of the Verband. On Saturday, a series of interesting visits to neighbouring works and industrial establishments has been arranged. Full particulars of this meeting can be obtained from the offices of the Verband at Viktoria Strasse 28, Mannheim, Germany.

FIRST 66KV CABLE IN AFRICA.—We learn that British Insulated Cables (South Africa), Ltd., an associate company of the B.I.C.C. Group, is to supply the first 66kV impregnated pressure cables to be used in Africa; they will carry a further 43MVA per feeder between Salt River and Oakdale. This work will form an extension of a previous contract, which involved the laying of three B.I.C.C. 33kV three-core solid cables between Salt River power station and the new Oakdale sub-station at Bellville, and two similar cables between the power station and the new substation at Elsies River. Two substations, and their local and rural distribution networks, were designed to meet the increasing loads placed on the Cape Western undertaking of the Electricity Supply Commission of South Africa. However, soon after this installation had been completed it was found that the feeders were operating at approximately 80 per cent of their full capacity, and it was decided that additional feeders would have to be provided. Accordingly two new 66kV three-core impregnated pressure cables will be laid between Salt River power station and Oakdale substation, a distance of about 11 miles, and a further 33kV cable between the power station and Elsies River, approximately 7 miles away.

PRODUCTION COURSES FOR SENIOR EXECUTIVES.—Following upon the summer course on "Work Study" held this year at the new Birmingham University Institute for Engineering Production, a series of short residential courses on the introduction and use of productivity study methods in industry, has now been arranged for works managers and senior production engineers. These courses each run for two weeks and may be attended separately or in sequence up to a total of six weeks. Each course will provide an opportunity for specialists in the work study, process development and operational research, and other productivity study fields, to exchange experience and to discuss practical application problems with industrial executives responsible for the introduction and development of productivity improvement work in their own companies. The courses will consist of lectures and group discussions covering the applications of work study, process and product study, production planning and control, and operational research, for the improvement of output and productivity. The year's programme will end with a five-day conference to discuss the problems of applying scientific and industrial research results in raising industrial productivity.

PRECISION MEASUREMENT IN ENGINEERING.—The College of Technology, Birmingham, has for some time played a leading role in the training of production engineers and in this connection two new courses are announced. The first of these, an advanced course for senior inspection staff and entitled "Precision Measurement in Engineering," will be held on Thursday afternoons commencing October 15th. It will consist of ten lectures each of two hours' duration which will be given by acknowledged authorities on aspects of metrology and inspection. The course has been arranged in co-operation with the Institution of Production Engineers as a means of promoting greater understanding of the principles and practice of measurement and hence a more efficient use of measuring instruments. The direction of the course is in the hands of Mr. T. B. Worth, head of the Production Engineering Section, and Mr. J. D. Morrison, metrology supervisor at the college. The other course is arranged as a normal sessional course on "Mechanical Engineering Inspection," and is suitable for those wishing to undertake a planned course of study in the theory and practice of inspection. It is intended primarily for students already holding technical qualifications and may lead to the award, in approved cases, of a certificate of the City and Guilds of London Institute.

Personal and Business

MR. W. TWADDLE has joined the technical staff of The Coleman-Wallwork Company, Ltd., Stotfold, Beds.

PROABD (ENGLAND), Ltd., has changed its address to 76, Victoria Street, London, S.W.1 (telephone, Tate Gallery 3311).

B. AND S. MASSEY, Ltd., Openshaw, Manchester, states that its chief engineer, Mr. Philip C. N. Pickworth, has been appointed a director of the company.

MR. L. E. MOLD, who has been a director of C. A. Parsons and Co., Ltd., Newcastle upon Tyne, for the past fifteen years, has resigned from the board on account of ill-health.

MR. F. W. LONG is joining de Havilland Propellers, Ltd., Hatfield, on October 1st to undertake liaison duties with operators of the company's propellers and other products at home and overseas.

MR. ARTHUR UPTON has returned to this country from the U.S.A. and is resuming his position as manager of the switchgear department of Johnson and Phillips, Ltd., Victoria Works, Charlton, S.E.7.

RHODES, BRYDON AND YOUATT, Ltd., Stockport, announces the appointment of Mr. J. Richmond and Mr. M. J. Hodgson as technical representatives attached to the London office at 28, Victoria Street, S.W.1.

MR. H. W. SWANN, M.I.E.E., is retiring at the end of the month from the position of senior electrical inspector of factories and electrical adviser to the Home Office. His successor is Mr. F. H. Mann, M.I.E.E., who has been deputy senior electrical inspector for many years.

MR. H. S. HVISTENDAHL, M.I.Mech.E., has resigned his position as chief engineer in the turbine division of Brush Electrical Engineering Company, Ltd., to become head of the investigation and tests department of Merz and McLellan, Carliol House, Newcastle upon Tyne.

MR. BONNER W. A. DICKSON, formerly a director and general manager of the aircraft section of Vickers-Armstrongs, Ltd., has joined the board of Flight Refuelling, Ltd., Blandford, Dorset. Wing Commander H. C. Johnson has rejoined Flight Refuelling, Ltd., as special representative.

VAUXHALL MOTORS, Ltd., Luton, states that Mr. Maurice Platt, M.I.Mech.E., its chief engineer, has been elected a director. Mr. Harold Drew, the company's former chief engineer, has resigned from the board on taking up his appointment in Detroit as assistant chief engineer of General Motors Overseas Operations.

VICKERS-ARMSTRONGS, Ltd., announces the appointment of Mr. G. R. Edwards, F.R.Ae.S., as managing director of the aircraft division, which comprises the Weybridge and Supermarine works, and of Mr. T. Gammon, M.I.Mech.E., as general manager of the division. On December 1st the following changes will be made in the engineering division:—Mr. W. D. Opher, M.I.Mech.E., to be general manager of the Elswick, Scotswood, Wakefield and Chertsey works; Mr. J. R. Kelly, to be general manager of the Crayford and Dartford works, and to take charge of the Whitehead torpedo works in place of Mr. Opher.

British Patent Specifications

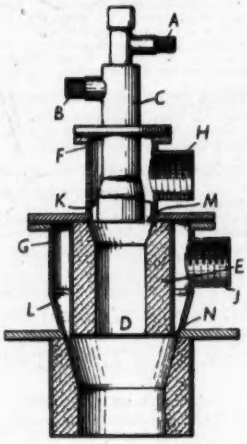
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 6d. each.

BURNERS AND SPRAYERS

695,722. July 26, 1950.—FUEL BURNERS, L. and C. Steinmüller G.m.b.H., Fabrikstrasse, Gummersbach/Rheinland, Germany.

The invention relates to a burner for combustible dust, dust laden gas or mixtures of other fuels and air, and its object is to provide means for cooling the refractory material lining the combustion chamber and for keeping destructive flames away, and to ensure a supply of oxygen to heavy unburnt fuel particles which move towards the periphery of the conical whirling jet due to centrifugal force and are ignited by heat radiation from the refractory. As the drawing shows, fuel flows through a pipe *A* and air through a pipe *B* into a central pipe *C* and the mixture is set in a whirling motion by means of



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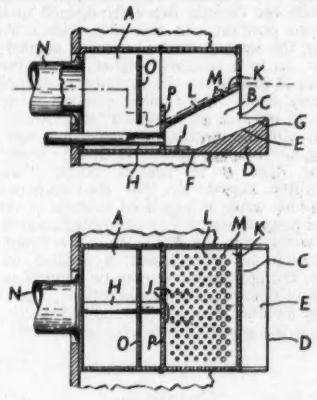
baffles inserted in the central pipe. The whirling jet formed in the pipe *C* then enters a combustion chamber *D* and is ignited. The combustion chamber consists of stepped co-axial chambers lined with refractory *E*. The pipe *C* and the upper part of the combustion chamber are encased by walls *F* and *G*, forming stepped annular chambers surrounding the pipe *C* and upper part of chamber *D*. A secondary supply of combustion-supporting substance, such as air or oxygen or mixtures thereof with coal gas or carbon dioxide, is supplied by pipes *H* and *J* to the annular chambers. Within the chambers baffles *K* and *L* set the substances flowing through them in a whirling motion. The secondary combustible supply flows from the chambers into each part of the combustion chamber *D*, through annular openings *M* and *N*, thereby simultaneously cooling the refractory *E* of the chamber on the inside and outside, keeping the flame away from the refractory and becoming itself preheated. The secondary supply enters at an acute angle with respect to the longitudinal axis of the burner by reason of the conical shape of the refractory where it enters and assists in the combustion.—*August* 19, 1953.

696,045. October 9, 1951.—DEVICE FOR BURNING OIL, Gordon Clayton Kemp, 79, Grange Street, Guelph, Ontario, Canada.

The invention generally relates to a burner of the vaporising type for burning low-grade oils. Referring to the drawing, it will be seen that the oil burner, or vaporiser comprises a casing formed with an air admitting chamber *A* and an oil vaporising and mixing chamber *B*, with a mouth *C* at its front end through which vapours and gases can move in a substantially horizontal direction. The base *D* of the chamber slopes rearwardly and downwardly from the open mouth as at *E* and merges with a horizontal portion *F* at the back. Preferably the base of the chamber is formed with an extension *G* that projects beyond the mouth in the same plane as the sloping portion. *H* is an oil inlet tube for admitting oil to the rear horizontal portion *F* of the base. The rear horizontal portion of the base has two upstanding ridges *J*, one on each side of the oil inlet tube *H*. These ridges serve to guide the incoming oil to a central position on horizontal base *F* and give controlled distribution of vaporised gases in chamber *B*. Primary and secondary air is introduced through a series of air jets spaced apart over a combined area over the base *D* of the vaporising and mixing chamber. The jets direct air downwardly on the base. The primary air jets are behind the secondary air jets and comprise a series of relatively small holes *L* in the rear portion of plate *K* at uniformly spaced intervals. The secondary air jets comprise larger holes *M* in advance of the holes *L*. The primary air is admitted for the purpose of vaporising and



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mixing with the oil vapours as they rise from the hot base. The holes *M* are large enough to ensure that the secondary air is added in sufficient amounts to achieve complete combustion of the oil after preliminary or primary mixing of oil and air. A motor-driven fan forces air in through an opening *N* of the air admitting chamber and around the baffles *O* and *P* down through the jet openings with sufficient force to cause it to strike the base. Baffles *O* and *P* are introduced to give an even distribution of the air over all of the jet holes. Baffle *P* is also provided to stop oil flowing back into the air chamber if at any time it became flooded.—*August* 19, 1953.

METALLURGY

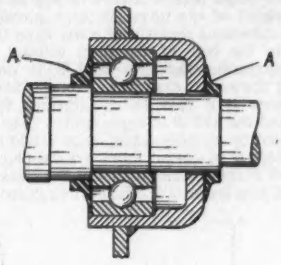
695,238. May 23, 1951.—PRODUCTION OF CONVERTER STEEL WITH LOW NITROGEN CONTENT, August Thyssen-Hutte A.G., of Duisburg-Hamborn, Germany, and Eisenwerk-Gesellschaft Maximilianshütte m.b.H., of Sulzbach-Rosenberg Hütte (Oberpfalz), Germany.

According to the invention refining is carried out in a converter in which, in the blowing position, the blow-holes in the bottom are only just submerged under the bath surface. The converter is not raised from this position by more than a further 30 deg. After the angle has been determined it is a simple procedure to raise the converter to the upright position and then to tip it over to the other side until the bottom is in the opposite corresponding position. When this method is employed it is advisable to enlarge the blow-holes, preferably to 20–30mm. In the process, blowing is effected during part at least of the blowing period with oxygen-enriched air. It is usually sufficient if this blowing with enriched air is carried out for 1–3 minutes, in which case the period of blowing time can be terminated with the end of the decarburising period. The oxygen available during the period of blowing with enriched air should be present in such quantities that, measured as gaseous O_2, it represents at least 30 per cent by volume of the blasting gas. The results improve with rising oxygen enrichment. Nitrogen contents of from 0·004 per cent to 0·005 per cent can generally be achieved with a blasting air containing about 60 per cent free oxygen. The heat surplus derived from the oxygen enrichment should be utilised by making scrap or ore additions. It is advisable to delay temperature compensation until the process is completed or until after decarburisation, to cool the bath during the dephosphorising period. The very short time of application of oxygen-enriched air enables working with reduced plant and low costs. The suggested alterations of converter shape are non-recurring initial costs and even then reconstruction may be carried out in adherence to the fixed converter replacement schedule.—*August* 5, 1953.

BEARINGS AND SUPPORTS

695,855. February 29, 1952.—DUST OR MOISTURE SEALS FOR SHAFT BEARINGS, The Westinghouse Electric International Company, 40, Wall Street, New York 5, U.S.A.

The ball bearing assembly is provided with rotating seals *A* at each end. Each of the sealing members consists of a circular member of resilient material, such as rubber, or any suitable material, which is preferably not adversely affected by heat or by contact with oil or grease. The sealing member has a central hub portion with a large bore which is tapered in. The sealing member also has a radial flange extending from the hub and tapered radially towards its outer periphery. In assembling the sealing member on the bearing the hub portion is forced



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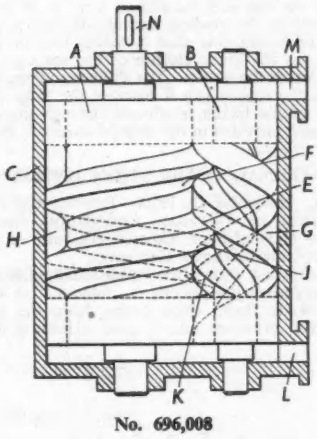
on the shaft so that the member grips the shaft with sufficient force to rotate with it. Because of the tapered bore, the flange is forced into a slightly cupped shape, as clearly shown in the drawing, so that the outer periphery of the flange engages the adjacent stationary part of the bearing assembly, which may be a part of the housing or the outer race of the bearing. Since the sealing engagement is only at the outer periphery of the flange there is relatively little friction and little or no rubbing noise when the seal rotates with the shaft. When the shaft is rotating the centrifugal force at the outer periphery of the flange is fairly high and this force tends to straighten it out. This effect is not sufficient to cause the flange to lose contact with the adjacent stationary portion of the bearing assembly, but it is sufficient to reduce the friction between the members, thus decreasing the wear and friction, so that the seal has a long life and does not produce any great amount of heat or friction loss.—*August* 19, 1953.

PRIME MOVERS

696,008. October 8, 1951.—SCREW ENGINES OR PUMPS, The Schiess Aktiengesellschaft, 289, Hansa-Allee, Düsseldorf-Oberkassel, Germany.

The drawing shows the invention in section. Two screw bodies *A* and *B* are mounted for rotation in bearings provided in a casing *C* by means of journals in the top and bottom of the casing so that their outer peripheries slide in the casing with a fluid-tight fit. The screw *A* has a larger diameter than the screw *B*. It is single-threaded and right-hand pitched, while screw *B* is double-threaded and left-hand pitched. Consequently, the left-hand flanks engage each other tightly at the spots, while the right-hand flanks do not engage tightly at *F*. There-



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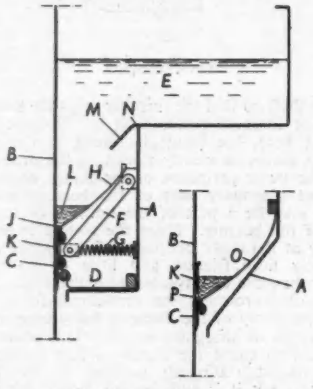
fore, the spaces *G* and *H* communicate with each other through the gap. On the other side of the screws, indicated in dotted lines, tight seals are established between the flanks of the threads at *J*, while no tight seal is established at *K*, so that only the spaces *G* and *H* communicate with each other and form together a chamber which is closed on all sides. Where the device is operated as a prime mover, the propellant fluid, water, oil under pressure or compressed air, is fed through the opening *L* and discharged through the opening *M*, or vice versa, depending on the desired direction of rotation, while the power is taken off from the shaft end *N*. Where the device is itself to be operated, such, for example, as a pump, the screw *A* is driven through the shaft end *N*, while the liquid or gas to be conveyed is sucked in through the opening *M* and passed into a tank or piping under pressure, through the opening *L*.—*August* 19, 1953.

GAS HOLDERS

695,095. May 12, 1952.—Water Removing Device for Disc Sealings of Disc Gas Holders, Maschinenfabrik Augsburg-Nürnberg A.G., Katzwanger Strasse 101, Nürnberg 24, Germany.

The object of the invention is to provide a continuous automatic removal of water from the sealing liquid in the cup of the disc, without requiring any supervision. The upper and lower views in the drawing show two examples of construction. The upper view is a cross-section through the sealing cup *A* and the wall *B* of a gas holder. The sealing is constituted by an iron sliding ledge *C* and its flexible connection *D* of cotton fabric or the like, with the back wall of the cup and oil filling *E*. The suspension of the sliding ledge *C* is effected by means of articu-



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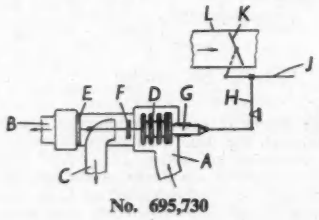
lated levers *F*. The application of the pressure is effected by pressure springs *G* or other members. An inclined guiding member *H* is secured to the upper end of the sliding ledges and this member catches the water drops from above into the cup; the water falls quickly into the sealing oil owing to its higher specific gravity, and reaches the upper edge *J* of the sliding ledge and the sealing gap *K*. In order not to affect the mobility of the sliding ledges *C*, the guiding member *H* is preferably made of a flexible material, such as cotton fabric, which is suspended from the back wall of the cup or stretched by a suitable device. For the sake of clearness, the figure shows a water layer *L* which, however, is not formed. A drip plate *M* is provided at the edge *N* of the cup and this plate covers the upper end of the surface of *H* and prevents the penetration of water into the space lying behind it. The example shown in the lower view differs from that already described in that the flexible connection *O* between the back wall of the cup and the sliding ledge *C* is inclined and replaces the guiding member *H* shown in the upper view. In this case it serves two purposes, namely, as the lower closure of the sealing cup *A* and to catch the water. The drainage of the water through the sealing gap *K* between the ledge *C* and wall *D* of the holder is effected through the outlet openings *P* provided in the ledge.—*August* 5, 1953.

INTERNAL COMBUSTION ENGINES

695,730. November 28, 1950.—Temperature Regulation in Internal Combustion Engines, The Daimler-Benz Aktiengesellschaft, of Stuttgart-Untertürkheim, Germany.

The drawing shows the invention applied to a water-cooled engine having a radiator. *A* is the cooling-water duct, which comes from the engine and which branches into a duct *B* leading to the



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radiator and a by-pass duct *C* short-circuiting the radiator and leading back to the cooling-water pump or to the engine. Arranged in the passage *A* is a thermostat *D* which carries two valve discs *E* and *F* for controlling the branch ducts *B* and *C* respectively. The thermostat *D* is supported by means of a slider *G* and is connected to a lever *H*, which is in turn displaceable by linkage *J* controlling a throttle valve *K* in the suction passage *L* of the engine. The thermostat *D* is influenced by the cooling-water temperature in the duct *A* so that at low temperature it keeps closed the duct *B* leading to the radiator, whereas the by-pass duct *C* is opened. With rise of temperature of the cooling water, the by-pass duct is gradually closed, whilst the radial duct is opened, so that the cooling water is conducted to an increasing extent through the radiator. In addition to this regulation of the cooling water there is a regulation of the basic position of the thermostat *D* in dependence upon the position of the throttle *K* such that, with the throttle closed, the slider *G* is located in its right-hand end position and, with the throttle flap fully opened in its left-hand end position. In this way, with low engine loading, the by-pass duct *C* remains opened longer (that is, up to a relatively higher temperature) and the duct *B* leading to the radiator is opened comparatively late; the cooling medium is therefore influenced towards an increased temperature. Conversely, with the throttle *K* opened and high engine loading, the by-pass duct *C* is closed earlier or the radiator duct *B* is opened earlier than with the throttle closed, so that the temperature of the cooling water is regulated towards a relatively reduced temperature and an intensified cooling action of the water upon the engine walls is brought about. When such an arrangement is applied to diesel engines, the thermostat *D* may be connected to the regulating linkage of a fuel-injection pump instead of to the throttle linkage *J*. A modified design is also shown in the specification.—*August* 19, 1953.

Catalogues

Higgs Motors, Ltd., Witton, Birmingham, 6.—September issue stock list.

Maiden and Co., Ltd., Hyde, Cheshire.—Leaflet describing Maiden threading machines.

Epping Engineers, Ltd., 73, Lindsay Street, Epping, Essex.—Leaflet describing the "Epping Auto-Shunter."

Joshua Bigwood and Son, Ltd., Wolverhampton.—Catalogue of ferrous and non-ferrous metal working plant.

Herbert Morris, Ltd., Loughborough.—Book 231, giving details of the new streamlined Morris pulley blocks.

Pioneer Oilsealing and Moulding Company, Ltd., Cottontree Works, Colne, Lancs.—Pioneer O-Ring Handbook.

Broom and Wade, Ltd., High Wycombe, Bucks.—Latest publications relating to "Broomwade" pneumatic tools.

Fyffe and Co., Ltd., Carolina Port, Dundee.—Pocket booklet on "Instantor" fittings for light-gauge copper tubes.

Superbuilt Products, Ltd., Bell Works, Harefield, Middlesex.—Leaflet giving full details of Harefield flexible doors.

The A.P.V. Company, Ltd., Wandsworth Park, London, S.W.18.—Publication indicating A.P.V. production facilities.

Steels Engineering Products, Ltd., Crown Works, Sunderland.—Publication entitled "Mechanical Aids to Cargo Handling."

Contracts

The Caledon Shipbuilding Company, Ltd., Dundee, has received an order for a twin-screw motor vessel for the Commissioners of Northern Lighthouses. The propelling machinery will be supplied by British Polar Engines, Ltd. The new vessel will replace the "Pharos," the Commodore ship of the fleet.

Ransomes and Rapier, Ltd., of Ipswich, has been awarded a contract for the construction of sluice gates and operating gear for the Government of Irak, worth £570,000. Ransomes and Rapier was the only British firm to tender for this contract, which was awarded, the firm states, not because it was the lowest in price, but because it offered the best design and quality of materials. The contract is for the Wadi Tharthar project, about 100 miles north of Baghdad and entails the construction, of seventeen barrage gates, each 40ft span by 16ft deep, and twenty-eight regulator gates, each 40ft span by 21ft deep, complete with operating gear. Nearly 4000 tons of material will be involved.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF BRONZE AND BRASS FOUNDERS

Thurs., Oct. 1st.—Clarendon Restaurant, Hammersmith, London, W.6, Informal Meeting, 12.30 p.m.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

Tues., Oct. 20th.—54, Station Road, New Barnet, Herts, Presidential Address, "Education and Training in the Electrical Industry," C. T. Melling.

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., Sept. 30th.—London Section: London School of Hygiene and Tropical Medicine, Keppel Street (Gower Street), W.C.1, "The Impact of Communication Theory on Television," D. A. Bell, 6.30 p.m.

Thurs., Oct. 1st.—N.W. Section: College of Technology, Manchester, "The Detection and Cure of Parasitic Oscillations in Radio and Electronic Equipment," H. Whalley, 7.15 p.m.

Thurs., Oct. 8th.—Scottish Section: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "The Microwave Test Bench and its Components—a Practical Introduction to Waveguide Work," J. Bilbrough, 7 p.m.

ELECTRIC RAILWAY SOCIETY

Sat., Oct. 3rd.—Fred Tallant Hall, 153, Drummond Street, London, N.W.1, "The Electric Railways of Merseyside," R. K. Kirkland, 3 p.m.

ELECTRICAL POWER ENGINEERS' ASSOCIATION

Mon., Sept. 28th.—London Local Group: York Room, Caxton Hall, S.W.1, "Earthing," P. W. Cave, 7 p.m.

INCORPORATED PLANT ENGINEERS

Tues., Oct. 6th.—Edinburgh Branch: 25, Charlotte Square, Edinburgh, Members' Papers, 7 p.m.—London Branch: Royal Society of Arts, John Adam Street, Adelphi, W.C.2, "Patterns, Casings and Foundry Work: An Introduction," Barnet Levy, 7 p.m.

Wed., Oct. 7th.—Southampton Branch: Polygon Hotel, Southampton, "Oxygen in Industry," E. Ryalls, 7 p.m.

Thurs., Oct. 8th.—N.E. Branch: Roadway House, Oxford Street, Newcastle upon Tyne, "The Use of Paint in Factories," P. J. Gay, 7 p.m.

Mon., Oct. 12th.—Dundee Branch: Mathers Hotel, Dundee, "Factory Instrumentation," 7.30 p.m.

Tues., Oct. 13th.—Manchester Branch: Engineers' Club, Albert Square, Manchester, "The Plant Maintenance Team's Visit to the U.S.A.," Colin Troup, 7.15 p.m.

Wed., Oct. 14th.—E. Midlands Branch: E. Midlands Gas Board Showrooms, Parliament Street, Nottingham, "The Works Engineer and the Factories Act," 7 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Wed., Sept. 30th.—London Branch: Waldorf Hotel, W.C.2, Presidential Address, B. Levy, followed by a Film and Report on "New Methods for Old," F. Hudson, 7 p.m.

INSTITUTE OF MARINE ENGINEERS

Mon., Oct. 5th.—85, Minories, London, E.C.3, "Ship-building," G. Ridley Watson, 6.30 p.m.

Tues., Oct. 13th.—85, Minories, London, E.C.3, "Operation of a Gas Turbine under Sea Conditions," J. Lamb, 5.30 p.m.

INSTITUTE OF PETROLEUM

Wed., Oct. 14th.—26, Portland Place, London, W.1, Redwood Lecture, "The Friction of Solids," F. P. Bowden, 5.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Wed., Oct. 7th.—London Branch: Royal Society of Arts, John Adam Street, London, W.C.2, Annual General Meeting, followed by "Transport in South Africa," T. F. Turton, 6.30 p.m.

INSTITUTE OF WELDING

Wed., Oct. 7th.—Slough Section: Community Centre, Farnham Road, Slough, Bucks, "Organisation for Production of Welded Ships," D. M. Kerr, 7.30 p.m.

Thurs., Oct. 8th.—N. London Branch: Manson House, Portland Place, London, W.1, "Automatic Welding," R. L. Swan, 7.30 p.m.—S. London Branch: 2, Savoy Hill, London, W.C.2, Chairman's Address followed by Discussion, "Weld Preparations—What is the Aim?" E. Fuchs, F. C. Cocks and D. M. Kerr, 6.30 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Sat., Oct. 10th.—Reynolds Hall, College of Technology, Manchester, George E. Davis Memorial Lecture, Norman Swindin, 3 p.m.

INSTITUTION OF CIVIL ENGINEERS

Thurs., Oct. 1st.—N.W. Association: Engineers' Club, Albert Square, Manchester, Address by the Chairman, C. C. Parkman, 6.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., Oct. 5th.—S. Midland Centre: Grand Hotel, Birmingham, Annual General Meeting, Chairman's Address and Conversazione, 6 p.m.

Thurs., Oct. 8th.—Ordinary Meeting: Savoy Place, London, W.C.2, Inaugural Address as President, H. Bishop, 5.30 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., Oct. 6th.—39, Elmbank Crescent, Glasgow, Presidential Address, Sir William Wallace, 6.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

Tues., Oct. 6th.—Automobile Division.—Storey's Gate, St. James's Park, London, S.W.1, Annual General Meeting, Address by the Chairman of the Division, 5.30 p.m.

Wed., Oct. 7th.—Southern Branch—Sussex Area: Downbarton, Grand Avenue, Hove, 3, Committee Meeting, 7 p.m.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Tues., Oct. 6th.—Ordinary Meeting: Institution of Electrical Engineers, Savoy Place, London, W.C.2, Chairman's Address, "Recent Developments in Subscribers' Apparatus and Services," F. C. Carter, 5 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Sat., Sept. 26th.—Shrewsbury Section: Works Visit to Josiah Wedgwood and Sons, Ltd., Barlaston, Stoke-on-Trent, 10 a.m.

Wed., Sept. 30th.—Shrewsbury Section: Technical College, Shrewsbury, "The Engineer's Part in the Production of Pottery," J. Robinson, 7.30 p.m.

IRON AND STEEL INSTITUTE

Wed., Sept. 30th to Wed., Oct. 7th.—Special Meeting in the Netherlands.

LIVERPOOL JOINT CHEMISTRY COMMITTEE

Fri., Oct. 2nd.—Arcadian Restaurant, Morecambe, "Retail Marketing of Motor Spirit and Lubricants in the United Kingdom," J. R. Higdon, 8.30 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

Fri., Oct. 2nd.—Engineers' Club, Albert Square, Manchester, 2, Inaugural Address of President, H. Wright Baker, 6.30 p.m.

NEWCOMEN SOCIETY

To-day, Sept. 25th.—One-day Visit to Haddiscoe and Lound (near Lowestoft) to see grasshopper pumping engines.